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PREFACE



Earth is an energy capture devise that maintains an average [surface temperature](#) of 59°F, converts [energy](#) into its many different forms, and is the only known conservatory for life. She is our perfect model of how to **collect, convert, and conserve energy**.

Buildings can be designed to replicate the activity of the planet. Buildings can collect, convert, and conserve energy exactly as the planet does. Energy conservation is based on equilibrium state conditions that prevail throughout the known universe.

The passive conditioning techniques that were abandoned because of the energy glut can be reinstated. The physics is still valid, and the practice is still common

throughout the world. We can reduce our electrical dependence by eliminating the need for air conditioning in rural low-rise homes.

Knowledge is our most precious resources. As expected, it is managed by those that manage the means of production. The reality that we know is as manufactured as any other product on the shelf. The global consumer economy has become the matrix of our thinking, and our reality.

Fortunately, we have options that don't require collective action and that remain independent of economy. We can design buildings according to the laws of physics rather than the economics of consumption. This back to the future program is built on simple, low-tech, no-cost house plans that the common man can build on his own individual building site. The homesteader can become the creator of a living symbiosis with his environment.

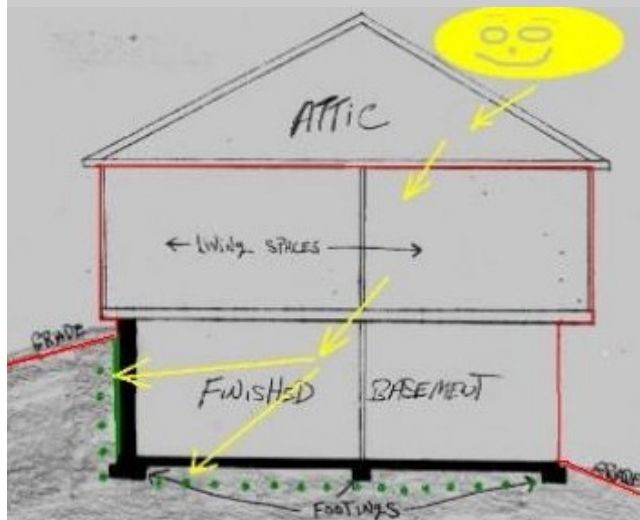
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INTRODUCTION

Buildings can be energy management systems that capture, convert, and conserve energy just as the planet does. To design such "environmentally interactive structures" we should know something about physics, environmental science, and ourselves. Of the three, the last is the most difficult.

The physics is pretty easy. Given two objects or regions in space with different temperatures, thermal energy will flow from the warmer to the cooler until they are the same temperature. In the end, the difference in temperature will be zero, and we say that $dT=0$.

This final condition where $dT=0$ can't be prevented except by adding or removing thermal energy. The condition where $dT=0$ is therefore called the final state, end state, equilibrium state, or limit state condition. In the end $dT=0$ everywhere.



Humans are happy when the temperature is around 72°F. Since the temperature of the atmosphere is hardly ever equal to 72°F, we constantly add or remove thermal energy from our homes. The exterior wall of a building is called the environmental separator. It is the interface between the interior and exterior climates. We would like $dT=0$ at this boundary, but it seldom is.

Soil temperature is much closer to 72°F than air temperature, much more constant, and a much less hostile exterior environment. This opens new possibilities.

We experience different forms of energy with our senses of touch, taste, sight, sound, and smell.

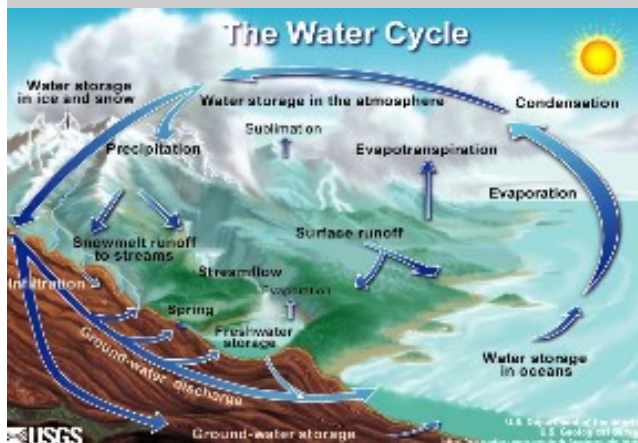
Each of these senses is triggered by the variation in density of the different forms of energy. Sound results from variation in vibrational density. Temperature is a measure of thermal energy or molecular vibration, which is what we feel as heat, and so on.

When we say that the final state condition is for $dT=0$, and that temperature will be the same everywhere, we are saying that thermal energy will be distributed equally throughout a space. This statement is true not only for thermal energy, but for energy in all its forms, and $dE=0$. Thermodynamic equilibrium is the final or equilibrium state condition in which all forms of energy are distributed or diffused equally. When that occurs the space is homogeneous and in a state of uniform energy density. The three forms of energy that are relevant to buildings are temperature, diffusion of moisture, and pressure.



Recall the surprise and delight you felt when you first discovered the see-saw, and how effortlessly you could move up and down. Recall too how it went bump when the board was not balanced. Everything has a balance point where there is no difference between this and that; $dD=0$.

There is great comfort, satisfaction, and peace of mind associated with such a state of equilibrium. We feel the same in the spring and fall when the weather is just right.



Because solar energy is constantly being added, the environment of our planet never arrives at a final state of equilibrium. But the natural flux occurs within certain limits of variation, and those limits depend on properties of matter. This gives us a certain degree of control, and we will study environmental science to see how our planet distributes this energy.

We will be looking for ways to balance the throughput of energy within our buildings. More generally, buildings and the properties that they are built on are little pieces of the planet that should have net-zero effect on the environment.

Sustainability and environmentally interactive are equivalent terms.

The most immediate difficulty with this is that we already have a vast supply of energy on hand, which leads us to consume rather than conserve. The well-being of the people tracks economy rather than

environment. We are led into an ever increasing demand for expansion. We know how to convert energy into either usable or unusable forms, where the first creates abundance, and the second creates scarcity.

This classification of energy as usable or unusable is important in our understanding. Electric cars, for example, conserve energy by converting the energy of deceleration into electricity which is then used in the next acceleration. In the gasoline powered automobile the braking energy is converted into frictional heat that is dissipated uselessly into the environment. In one case the energy is converted into useful form. In the other case it is converted into an unusable form.



Man has mastered the art of manipulating energy, but we don't always do this in the most appropriate or sensible way. Air conditioning of buildings, for example, opposes the second law and thereby creates an enormous amount of [waste heat](#) that is dumped back into the atmosphere. This is one of our most costly and destructive energy practices. This paper will demonstrate that electrically driven air conditioning is unnecessary in low rise buildings. Older passive conditioning techniques, combined with modern technology is quite sufficient.

There is story, almost a myth, about a remarkable little black box that contains vast amounts of energy that is ours for the taking. Some have said that this box is some kind of fuel cell, and others have said that it is some kind of device that captures cosmic radiation. Both are

wrong.

The box does exist, but it does not contain the energy. The energy exists in the universe, and the box contains only the knowledge of how to manage [Capture/Convert/Conserve] that energy. Recall that the average or equilibrium temperature on Earth is already 59°F by the very nature of things, and that this protected environment is our point of beginning. In many parts of the world, [average temperatures and rainfall](#) are quite able to sustain reasonable populations without the problems that excessive energy use has created.

To convert the chemical energy of gasoline into an accelerating force, for example, the driver pushes the gas pedal. Too much is no better than too little, and our species has shown very poor judgement in regard to energy balance, equilibrium, and other concepts of stability and sustainability.

Living within the natural limits of the planet doesn't mean any loss in comfort. It means doing things differently. It means aligning ourselves with the energy principles, and observing the natural limits of the planet. There is a time for growth and expansion, and that is the youth of an organism. But truth and time change, and so must behavior and lifestyle. Our planet is people poor, and our people are energy poor, but continued population and economic growth is deemed necessary.

This article is a do-it-yourself-now instruction manual that describes how to build structures that do not require mechanical air conditioning. This approach will not work in the city which lacks a living, natural environment with which to interact. Rural settings and forests that welcome the natural forces of earth, air, fire, and water will do, where fire is simple sunlight rather than fossil fuel combustion.

This knowledge base is built upon our experience with the world in which we live. Specifically, we will reconsider our energy transactions in buildings, not in terms of current marketing gimmickry, but in terms of real conservation principles and sensible choices.

The first principle is the Goldilocks principle which says that by preventing things from becoming too much, or too little, they will be Just Right! This principle works everywhere. Our atmosphere, for example, blankets the planet and prevents it from getting too hot or too cold. Since it is neither too hot, nor too cold, it is just right in sustaining the conditions for life on Planet Earth. Goldilocks and sustainability are sister and brother.

What is not always just exactly right, is always close. Of the three bowls of porridge, only one was just right. But if Goldilocks had mixed the other two together, they too would have been just right, and her available resources would have been greatly increased. When we draw our bath, we mix too cold and too hot together to get just right. Goldi is there!

Summers are too hot, winters are too cold. Spring and autumn are just right. If we can collect the surplus heat of summer and add it into the heat deficit of winter, we might maintain a year round average temperature that is close to that of spring and autumn. We can eliminate thermal energy extremes by long term averaging, just as we do with water.

The basic strategy for conserving resources is to provide storage capacity. This allows us to collect a resource when it is available, and store it until needed. We store thermal energy with [thermal mass](#). All matter exhibits the property of heat capacity which is the ability to store thermal energy. Conservation of thermal energy is facilitated by installing sufficient thermal mass in buildings to prevent over-heating. Excess energy, thus stored, remains available to prevent over-cooling at a later time. Long-term [summer to winter] thermal storage is facilitated in time-lag or thermal flywheel techniques.

On the other hand, If we wish to create an imbalance of energy in buildings, which creates the need for additional energy, we should eliminate thermal storage, which is exactly what we do. What we do instead is to insulate, which is an attempt to prevent heat from flowing from a warmer to a cooler region. This opposes the 2ND law of thermodynamics, and is nothing more than an added expense. From the 2nd law of thermodynamics, we know that energy distributes itself evenly, and that we can prevent this only by adding additional energy into the system. Without adding energy, the inside and outside temperature, pressure, relative humidity, etc of a building will be the same. To prevent this, and maintain year round differences, we add the energy of heating and cooling.

Planet Earth maintains a [surface temperature of 59°F](#). This is 33°F higher than expected, and by observing how that happens, we might repeat the same processes to maintain an interior temperature that is 10-15° higher than the exterior. This would eliminate the energy loads on our buildings and result in the [energy neutrality](#) and zero remainders that is associated with sustainability. To do this would be "thermodynamically correct".

While we cannot achieve this completely, we can implement the strategy, and go a long ways towards that. By reintroducing passive conditioning techniques, energy driven heating and cooling systems can be demoted to backup status, and greatly downsized.

Since man does not follow the principles of physical law that maintain homeostasis on this planet, he remains unprincipled. He may claim to have principles, but that is not the reality. This consciousness, too, is part of the essential knowledge. We can amend this situation by focusing on resource management and environmental protection, which is intimately connected to sustainable energy management.

To construct buildings that capture energy from the environment, we need to design them around concepts of thermal mass, material properties, time-lag energy distribution, and other essential

properties and reflections of steady state conditions.

The absence of steady state conditions, and the degree to which they have been engineered out of existence in the man made world is absolutely astounding. This article will include a discussing of their importance as architectural elements in building design only. Other examples can be found throughout man's history and culture, as in the examples below;

- [Carrying capacity](#)
- [Ecological footprint](#)
- [Equilibrium](#)
- [Evolutionary economics](#)
- [Homeostasis](#)
- [Steady state economy](#)

"The benefits of a steady state economy can be grouped in three categories: environmental, lifestyle, and moral. Environmental benefits stem from the establishment of a steady state economy at a sustainable scale. An economy with stable population and consumption features decreased liquidation of natural resources and less waste deposition in the environment. Such an economy that respects biophysical limits does not excessively disrupt natural ecosystems and ecosystem services. It is right-sized to balance with nature and protect the life-giving resources and processes of the planet. The lifestyle benefits of a steady state economy are numerous. Life is downshifted as over consumption, congestion, sprawl, and unfair trade practices fade away. Efficiency is still valued, but the tasks for which we seek maximum efficiency are more carefully considered. People have more time and inclination to focus on community, relationships, sufficient consumption, and other important life matters. Establishment of a steady state economy also can provide significant moral benefits. First, on a planetary scale, limiting growth in nations that enjoy high levels of per-capita consumption would leave more room for economic growth in those nations where citizens are getting by on low levels of consumption.^[25] In the long run, preventing over-consumption in the present leaves greater opportunities for future generations to meet their needs. Finally, limiting growth can lower the percentage of planetary resources appropriated to human economies, resulting in more room for nature and continued evolution of ecosystems and species."

When we look at the energy flow through our own species, we have got to be alarmed. In particular, the amount of energy that we dissipate back into the environment is not at all close to anything that will sustain planetary homeostasis. This human footprint, the pressure that man puts on the planet, is enormous and unnecessary.

This is not rocket science, but we will talk a bit about that a bit in order to accentuate this. The task of a rocket engine is to burn [release] energy fast enough to achieve escape velocity without exploding. A rocket is essentially a controlled explosion, and the line between a rocket and a firecracker is very thin. Rocketry too, is an energy management system but with very specific purposes and timescales. While we are capable of managing that level of disequilibrium, we can do so ever so briefly. It is a state of controlled disequilibrium.

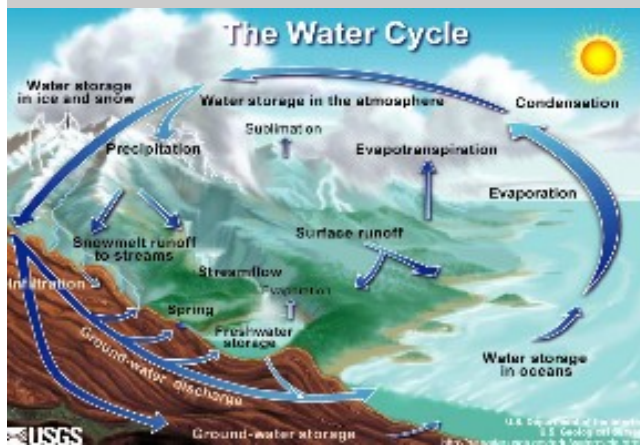
The controlled expansion of the consumer economy in order to maintain full employment is likewise an energy management system that stands in opposition to the thermodynamic laws. Both are non-sustainable systems disequilibrium.

John Kennedy once quipped that we would succeed in getting to the moon "not because the technology is easy, but because there is no serious opposition to that". We close this preface with the statement that: If we fail to develop a responsible energy management policy, it will not be because the technology is difficult, but because of the serious opposition to that.

Regardless of all that, this paper is a cook book that contains the basic recipe for buildings that conserve energy by "hooking into" the available energy that surrounds us.

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ENVIRONMENT, PROPERTIES, AND PRINCIPLES



Sunlight and water are inseparable traveling companions on Planet Earth. This is to be expected because it is sunlight that drives the water cycle. In this light, we see that the water cycle distributes solar energy, and water, to all points of the planet.

Actually, the image is a representation of the [Biogeochemical Cycle](#). Another name for this is the Nutrient Cycle.

How we understand a thing is deeply embedded in the words that we use to describe it. Just as the words time and space are better understood as space-time, which presents a totally different picture of what it is that we are talking about, we must consciously reconfigure our vocabulary. Words are the fodder of the masses.

For purposes of reconsideration, the water cycle might be thought of as the enthalpy cycle. It is an energy transport system that distributes the sensible and latent heat of water as well as water itself. Notice also that a cycle is a system of distribution, and that something can be distributed to a different point in time as well as to a different point in space.

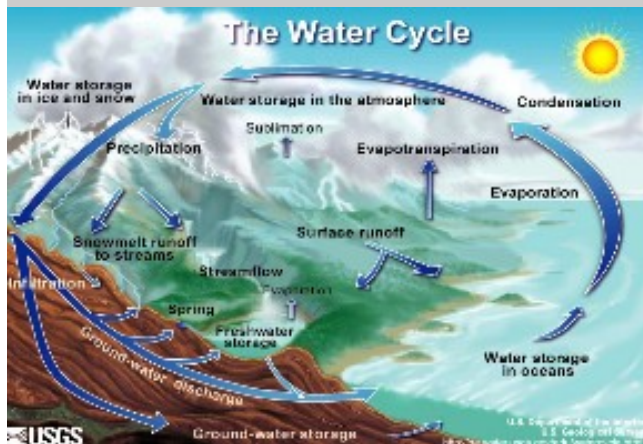
As consumers, our thinking is as much a manufactured product as the products on the shelf. If we are to become a conservative part of our planet, we must quit thinking and acting like consumers. Conservation requires a new vocabulary and an updated mind set. Buildings that are designed to be extensions and refinements of the environment will conserve environment, energy, and life exactly as the planet does. Buildings that replicate environmental processes will cooperate with, rather than oppose, environmental forces. This is the mother load!

Our ability to construct environmentally interactive structures will require an exact working knowledge of the environment, and a deep understanding of basic principles. To do this, we will look at the properties of

matter and energy that order the activity of the entire universe . Evidence indicates that Life is nothing more than energy that has attained consciousness. Certainly Life is not independent of energy and its ordering principles. In our opposition, we remain totally unprincipled and undisciplined. Perhaps this is why we are such a disturbed and disturbing species.

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PRINCIPLES OF CONSERVATION



The image is actually is a flow chart. It shows how solar energy and water are distributed to all points on the planet. As a rule, nature corrects her own deficiencies in order to maintain equilibrium.

This is the principle of conservation. Differences in air pressure, for example, that are caused by unequal heating of the planetary surfaces, results in wind, which is just the flowing of air from higher to lower pressure until the pressure is equal everywhere. Nature annihilates deficiencies and surpluses alike. Without energy input, equilibrium conditions prevail

As another example, thermal energy flows from a body of higher temperature to one of lower temperature until they reach the same temperature. When their temperature is equal they are in thermal equilibrium, and there is no further flow of thermal energy. This increase in the unavailability of energy is called entropy. What it means is that energy is diffused, dissipated, and distributed equally throughout. This is the second law of thermodynamics in action.

This tendency towards equilibrium can be thought of as the law of vanishing differences. It applies to heat, pressure, molecular distribution, gravitational potential, and other stuff. Everything will eventually come "to rest" in what is called a final state condition. This is the so called heat death of our solar system.

But until the sun quits shining this will not happen on Earth. In the meantime, the conversion of all this energy into its many different forms creates either the conditions for life, or life itself, depending on your viewpoint. Some would say that life is simply energy that has attained consciousness. Most would agree that life can not exist without energy. At any rate, this planet remains in a state of disequilibrium which can only be attained by inputting energy. Otherwise it would move to steady state. Unless some form of energy is brought to bear in order to lift water to a higher elevation, for example, all water will remain at sea level, and that will be the final state condition of water on the planet.

Similarly, the "pop" of a balloon is caused by the release of energy that is embedded in the maintenance of a pressure difference across the boundary. This pressure difference was created by the energy required to inflate the balloon. No energy, no inflation!

In the end, equilibrium state conditions prevail. This is wonderful because if those final state conditions are acceptable, we can enjoy them from now on without doing anything further. In the meantime, we can observe how the living environment of our living planet functions to limit the extremes of natural variation on the planet. It is important to note that natural variation is limited but not eliminated.

The greenhouse effect, for example, goes a long ways towards blanketing us from the violence of empty space. Our atmosphere limits temperature variation at any given location on the surface to about 100 degrees F. This conserves the conditions for life, and shows us how to refine that same process by simply repeating it. By replicating our atmosphere, we construct greenhouses that extend the growing season. Our approach is to copy the natural world.

We'll look at differences or differentials or "gradients" across boundaries more closely later, but for now the point to be made is that differences can be maintained only by imputing energy. For example, without a heat source, the interior temperature of a building will be close to the outside temperature. To change the interior temperature we can either input energy, or wait until the outside temperature changes.



The problem with imputing energy in order to create a state of disequilibrium is that it opposes the conservation principles which almost always push back. Opposing natural law can become very expensive.

The most instructive example of our opposition to Nature can be seen as the condensation that collects on the outside of a glass of ice water. Observe that this will not occur until we add ice.

Matter commonly occurs on Earth in three forms, [solid, liquid, vapor] the current form being determined by the current temperature, which is an indicator of energy content. Energy transferred into or out of a material causes a phase change of the material. Condensation occurs when water vapor changes into liquid water. It is a process of energy transfer. When

water vapor releases energy to its surroundings it changes into liquid form. This will continue to occur until the ice has melted, and the water inside the glass has reached the same temperature as the air outside the glass. Water vapor is always present in the air. The latent energy of phase change is the energy that is released when water vapor condenses back into liquid water. The thermal energy that is released flows through the glass, into the water, and melts the ice. The whole process of phase change is a thermodynamic process of heat or energy flow. It is a natural process.

Liquid water in oceans and lakes soaks up solar thermal energy [sunlight] and changes from liquid to vapor, which then diffuses into the air, which is in turn heated, expands, rises, and moves to an area of lower pressure. Everything moves from high to low, and this again is the second law of thermodynamics that allows us to know exactly where, and in what form, we will find the original solar energy. Rain occurs when water vapor [clouds] condenses into liquid somewhere inland, and often high up. The gravitational potential energy of falling water can drive a turbine. We can use this knowledge about our environment to design buildings.

Latent energy or phase change equilibrium is one of the basic forms of energy conservation, and one of the most violated principles in building construction today. Condensation does not occur when the temperature gradient across a boundary is equal to zero. A glass of room temperature water will show no signs of condensation. We must add ice before we can create condensation. We must create the temperature and moisture gradient. And we do!

To create condensation inside the exterior walls of our homes, we won't add ice cubes, but mechanical air conditioning is just as good. When the outside air temp is 90 degrees F, and the relative humidity is 90%, and we apply enough electricity to cool the inside to 78 degrees and 50% relative humidity, the dew point is nested within the environmental separator which is therefore a condensing surface. Entrapped moisture is a nightmare. To see what becomes of trapped moisture, leave a basket of wet clothes somewhere for a few weeks.

We can prevent condensation by reducing the temperature gradient, the moisture gradient, or both. What we actually do in the home of today is to increase both gradients. As the outside temperature rises, we apply more electrical energy. This increases condensation.

There are three obvious ways to prevent condensation within the exterior walls. We can reduce the temperature gradient or we can reduce the moisture gradient. The third way is to change the conditions of the outside environment.

We can't do that in the summer atmosphere, but we can do exactly that in the below grade soil which maintains final state temperature and moisture conditions much closer to what we want in our interior living spaces. The gradients of temperature and moisture are much smaller below grade than above, and can therefore be maintained with much less energy input. We don't have to remain in opposition to the solar overload of the summer atmosphere. We can relocate our structure to a less hostile environment. We can rely on the thermal properties of matter [soil] to reduce the environmental pressure on our building. This can be seen as an act of resource conservation or as an act of environmental protection. It is both.

Additionally, we can recreate this below grade environment above grade. We can stay cool, even above grade, by reintroducing thick and massive masonry and earthen materials that soak up [absorb] both heat and moisture, and then release it later in time. This capacity to store energy [heat and moisture] and release it later, distributes energy over time. Our task is to discover ways to enhance and extend this process. Using solid masonry walls that are insulated on the outside is just one example of this.



When we live in environmentally interactive buildings that are designed to be extensions and enhancements of the natural environment, we alter our consciousness as well. A structure that is connected to nature provides a different aesthetic experience than one that is isolated. The picture above shows a little remaining sunlight on an autumn afternoon.

Buildings, like trees, create their own interior and exterior micro-climates. Micro-climates add up to environment. We will look very closely at the nature of our environment in order to design buildings that process environmental energy. We wish to stop opposing The Nature.

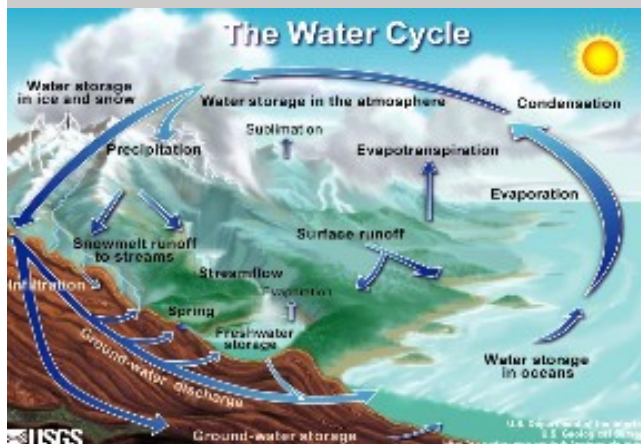
One view, for example, conceives of a building as a process of filtering and refining the environment, and is a form of environmental management. Interior brightness, as another example, should vary throughout the year. Shape, position, and orientation of the structure should manage solar penetration. The interior should be shady in summer and full-bright in winter, which is an effective control over interior thermal energy. This also provides the opportunity for setting up a sun dial in the living room during the winter months only. During the summer it must be moved just outside the windows, but it is always a wonderful conversation piece.

Buildings that are heated by some form of fuel combustion (wood, gas, oil) face an added tax. Any combustion process exhibits [stack loss](#) which adds to the energy load. Any structure that has a chimney incurs a cost plus energy expense.

Structures that rely on environmental filtering may, in a sense, exhibit negative stack loss. If the backup climate control system is an earth coupled heat pump: 1. The chimney is eliminated; 2. The energy

[enthalpy] of maintaining a temperature difference between the interior and exterior is greatly reduced viz passive conditioning techniques; 3. Because the intake air is cool in summer and warm in winter, the structure itself is a "chimney" that may effect a negative stack loss. For example, a [solar chimney](#) may drive the ventilation (cooling) system in summer, while in winter the intake air may be warmer than the interior air. Both of these processes are in keeping with, rather than in violation of, the 2ND law. Both processes therefore lead to final state, end state, limit state, equilibrium state conditions very close to human comfort zones.

In short, we wish to boost the interior ambient temperature of a building to about 15°F above that of the original [surface temperature](#) of 59°F. Additionally, we wish to hold the internal temperature of the system very close to this new average by establishing conditions of steady state that limit the variation of both components (sensible and latent heat) of enthalpy. Planet Earth maintains the conditions for life, we wish to add conditions for comfort.



The Greek Mind thought of the four substances- Earth, Air, Fire, Water- as the Creation Elements, the fundamental stuff from which the entire universe is made. Today we think of them as the renewable energy sources. They are the transport processes that distribute energy throughout the planet. They are the biochemical processes that are involved with the distribution of essential nutrients on Earth. They are the beginnings of the biosphere.

In this process, a tree is both cause and effect It is created by, and creator of it's natural environment . A tree is the environment. All

together, these objects and processes either constitute the conditions for life, or they are life , depending on your viewpoint. Life and energy, and the nature of their interaction is the essence of what happens on planet Earth. The creator and the creation seem one and the same entity. To the Greeks, this entity was Gaia, and the world was one living organism that maintained homeostasis through these elemental interactions. Fire and Air led upwards and outwards. Earth and Water led downwards and inwards. This world view was the basis of Greek science, culture, engineering, and medicine which still prevail today. These processes of energy transformation are the creators of our dynamic, living, fluid world in which life and energy may be different words for the same thing. Life may be nothing more than energy that has attained self awareness.



Eastern thought reflects the same basic ideas as that of the western world. [The Cosmic Dance](#) of Brahma, Vishnu and Shiva symbolizes the interaction of the three forces of Creation, Preservation, and Annihilation that maintain the world in the "eternally present now". This, very much like the image of the water cycle, conveys the idea of a world that is continually brought into being. They seem a process of energy and matter, rather than subject or object. The world is an activity.

Greek and Hindu thought are reflections of one and the same truth. As highly accurate descriptions of how our natural world works, they reveal basic principles that we are going to explore very deeply. We wish to not oppose natural law.

This statue stands at [CERN](#) as a symbol to the cycle of creation and destruction that is manifest, not only in the life and death cycle of organic

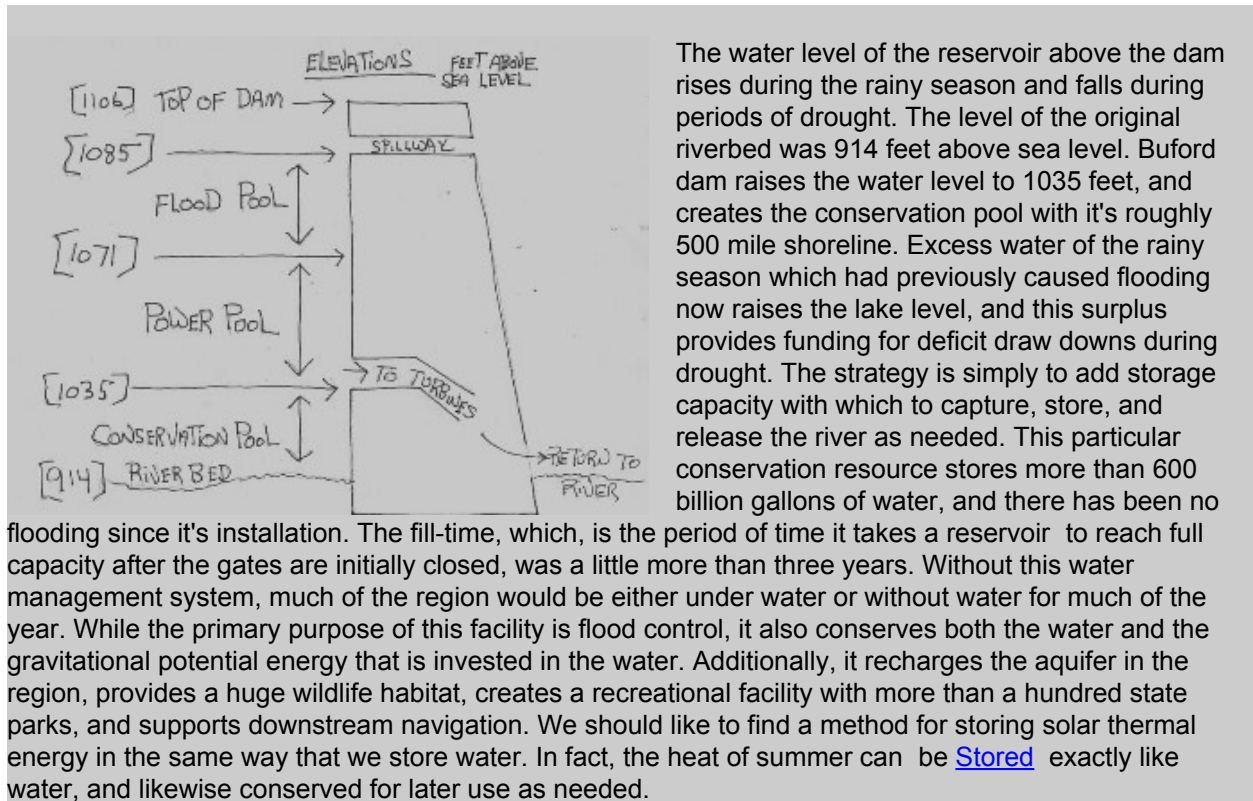
matter, but also in the dance of the subatomic particles of inorganic matter.

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PUBLIC WATER SUPPLY: A RESOURCE MANAGEMENT MODEL

The damming of a river is a simple strategy that prevents flooding by regulating the amount of water that is released back into the river downstream of the dam. While rainfall and the resulting inflow into the reservoir varies greatly, the outflow is held somewhere close to a long term average. In this way, flooding is prevented, and the water that would have been lost to flooding is "added-into" the supply pool that is available for our use. A dam manages the downstream flow of the river. It distributes the flow of the river over time, and this "clips-off" the extremes of natural variation in the water cycle. Flood prevention is our most direct form of water conservation, and the first base of environmental protection. As a case study of this strategy, consider [Lake Sidney Lanier](#).

The simple schematic below shows how a water reservoir conserves water.



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PASSIVE CONDITIONING TECHNIQUES

There was a time when the American home was built with heavy masonry materials that were able to soak up both excess heat and moisture, store those excesses, and then release them later as needed. This tended to limit the peaks and valleys of temperature and moisture variation inside the home, and hold the interior climate to a more comfortable average. Masonry building products have been used throughout the world because of their fail-safe storage capacity for both heat and water. This "capacity" for storage is the basis of both resource conservation and environmental protection on our planet.

In the 20th century, cheap energy, mass production techniques, economy of scale, and other factors, all coalesced into the concept of disposable resources. The building industry introduced the electric air conditioner, and this led to a totally different strategy of how a building is designed to function.

Instantaneous, on-demand, heating and cooling provided complete isolation and independence from the outside environment. Regardless of any outside climatic or weather conditions, we could control the interior climates of our homes at the dial of the thermostat.

Passive conditioning techniques were no longer necessary. This eliminated the need for architectural constraints of any kind. Homes could be built quicker, lighter, faster, and cheaper. They could be manufactured on wheels, and dragged onto the building site. All forms of passive conditioning were abandoned, and the interior climate was now totally dependent on the active input of energy. This of course requires the uninterrupted availability of active energy, and this can lead to Titanic surprises.

In terms of quality, today's American home has reached an all time low. It is a product of marketing and financial engineering that is as divorced from good physics as the fast-food menu is from good nutrition. The materials are substandard, and the results disastrous. In particular, the hollow walls of our building enclosures are wonderlands of trapped moisture, mildew, mold, and fungus.

The intersection between good buildings and good economics is not technologically difficult. It is, in fact, quite possible at the local level in a rural economy. It depends on the use of labor and materials that have been available for hundreds of years. It requires common skill sets like brick laying and stone masonry that many have, and this allows the common man to have a life, and participate in his life. Solid masonry walls eliminate the problems of hollow walls.

This type of construction is not only better suited for low-rise buildings that lay cool and close to the earth, but it is more labor intensive and provides employment for the common man. This provides the people with a more active lifestyle in rural surroundings. It avoids the mixture of urban problems that is insurmountable to many. It is a healthier mix of humanity, economics, and environment. For those that are no longer intoxicated with the glitter and glamour of big city life, it offers the option of a "good lifestyle that works". The intersection of healthy lifestyle, natural environment, and gainful employment is a powerful incentive to able bodied men.

Most importantly, it puts resource conservation and environmental protection back into the hands of the people. The dispersal and diffusion of knowledge and technology within the public domain is an important element in maintaining a symbiosis between our species and our planet. Governments talk about environmental protection, but this is a struggle between business as usual, and planetary welfare. The people have very little part in it, and are left to sit on top of the supply lines for food, water, electricity, and other utilities, without which their homes are uninhabitable and valueless. In this context, the ability of a landowner to create his own energy, and the independence of mind that goes into that, could be crucial to the survival of our species. Some would say that a lion has to hunt, and that a man has to create; that neither can exist as mere consumer. America has a history of rugged individualism, and the homesteader may rock again.

The development of renewable energy sources is not going to be quite as wonderful as we are told because it will be converted into electricity rather than heat, food, or shelter for the people. It will be corporate owned means of production that will allow further expansion of populations and markets, but of no real benefit to the people or the planet. It will be business as usual. The bigger thing that we are not told is that producing electricity depletes water supplies.

The development of alternative energy sources by the large energy companies will not alter the course of environmental depletion that we are on. We need something more than alternative energies. We need

alternative economies, alternative societies, and alternative realities that promote conservation rather than expanded consumption.

This may require some totally different organizational principle that leads to the distribution of wealth among the people as in previous agrarian societies. Farmers, gardeners, and others that remain close to the land have totally different values than large corporations. Additionally, they are not able to become "too big to fail". Open source and the Internet may become crucial to our evolution.

The worst part of a crash is in the moments when you can do nothing except watch it coming. There is a certain exhilaration in surviving a crash, and so the aftermath is often not as bad as the anticipation that preceded the event. This is how individuals and species mature, and how directed adults emerge from undirected children. It is difficult and yet rewarding. We might begin to experience an alternate reality that has more to do with an awareness of species longevity and planetary stewardship. We might realize that monopoly was really a poor organizational principle for our species, and that we are capable of some much higher calling.

We might recall [Carl Sagan's](#) thoughts that Man's consciousness might be the spearhead of the universe's search for Self Understanding.

Because nature has stored sunlight for us in the forms of coal and oil, we have been released from the need to collect and store sunlight in the present tense. We have fallen upon an energy wealth of such vast abundance that all considerations of conservation, deficit, and deferred costs have been forgotten. We have fallen into some really bad habits. The consumer economy has become the Matrix of our thinking. This particular man-made reality is so ingrained into the core of modern civilization that we cannot even imagine that there are alternative realities that are based in alternative technologies. In the wake of some game changing "event", we might reconsider the advantages of conservation.



flow-through fluids.

The rocks in the picture came from a stone wall that was built when the site was cleared 50 years ago. Reordering them to terrace the back yard was hard work, but rewarding.

New civilizations are often built from the ruins of the previous, and there is no reason to believe that the process will end now. We have to love what we are going to leave behind. Energy can be conserved for future use just as easily as rocks, water, or other resources.

It won't wear out, and we begin not at zero, but at the average temperature of 59°F. Besides that, energy and water, unlike rocks, are

Good buildings are based in resource conservation and environmental protection. Both are realized through the "best use" of resources and materials. Buildings and shelters can be designed to interact with and conserve their natural environment rather than oppose and consume it. Some of these techniques are very old, and some are new. They are based on simple principles of physics. They are low-tech, on-site, hands-on, techniques that belong to the people, and can be implemented at home by the homesteader.

The few people that turn back to homesteading, rural lifestyle, and relative self-sufficiency will be an independent and creative bunch. In the 20Th century, as people flocked to the city in search of the good life, only the most determined stayed on the farm. In the 21st century only the most determined will move back. But a man gains a lot when he takes up his own work in place of someone else's, and many of today's self-employed entrepreneurs will find that the exchange of goods and services in rural settings has its advantages. There is no final frontier because the pioneering spirit will always create a new one. The Brits already learned that.

The eminent business leaders of our times predict that because of a doubling of world populations and attending markets in the next 50 years, the economic forecast is good. Evidently they do not know what a doomsday machine is, or what life will be like in a world of 12 billion people. That world will be something like today's airports; no animals or trees. Who could live like that? We can build something better than that.

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MATERIALS OF MASS CONSTRUCTION

To design homes that are durable, functional, and conservative of our environment, we will first use these principles to choose the materials from which to construct our buildings. Since energy distribution on our planet is so intimately connected to the marriage of heat and moisture, we will want to use materials that will tolerate variation in both thermal and moisture content. We want materials that can cycle through hot and cold, as well as wet and dry, which is to say that we want materials that can store and release both thermal energy and moisture. Some of the oldest and least problematic materials we have are the masonry products. Products such as brick and adobe are hygroscopic [water absorbing], and some are hydrophilic [water loving].

Building materials and construction methods have changed over time from labor intensive uninsulated assemblies of natural materials to labor efficient assemblies of engineered products that result in more comfortable and highly energy efficient buildings. Current construction is much more air tight and highly insulated than those of old. Unfortunately, in terms of resistance to moisture damage this higher performance comes with a price. Current construction is less forgiving of shortfalls of design and construction than were those of the past. Current buildings are tighter and better insulated so they are able to maintain draft free environments with comfortable levels of temperature and humidity. The ability to maintain comfortable levels of temperature and humidity inside buildings increases the psychrometric stresses driving moisture into the building envelope. Any defect in modern assemblies results in a large impact as present day construction has less moisture storage capacity than those of the past. Also, the high performance engineered building materials in current use include hydrocarbon based materials such as paper and resins that are subject to attack by mold and bacteria.

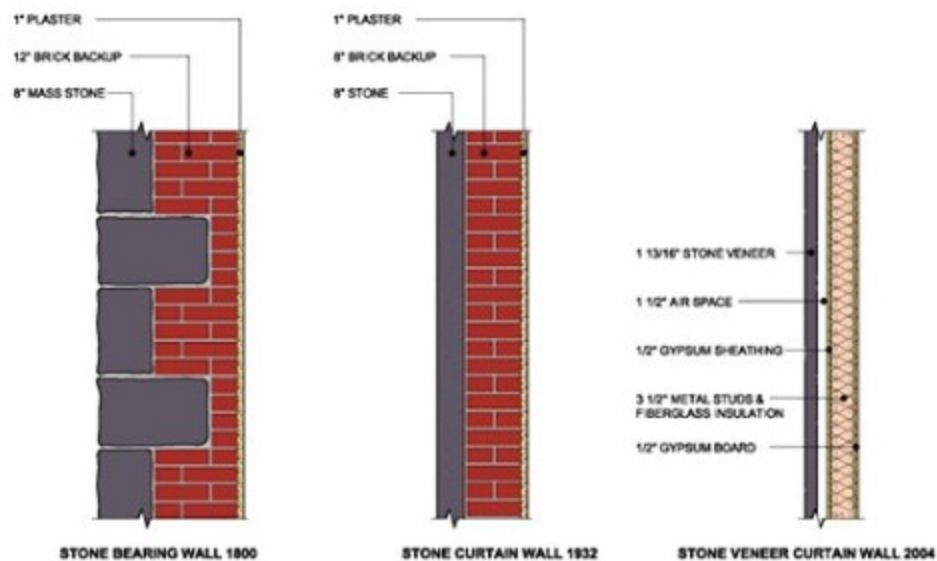


Figure 1. Wall Construction from the 1800's, 1932 and Now

Drawing 1 shows bearing wall construction common in the 1800s, masonry curtain wall construction from the 1930s and current construction using metal studs. The construction of bygone eras included masses of masonry that could store moisture impacting the wall. Current construction provides an air tight insulated envelope, but has little moisture storage capacity.

[Materials of Mass Construction](#) have been in use throughout the world from the time that early man upgraded from cave to atmosphere. Rock and stone were the first building materials, and continue to be used extensively because of their thermal storage capacity and their moisture storage capacity. These properties of thermal mass and hygric buffer capacity, are more important than ever in a world of increasing energy costs. The intrinsic properties and nature of these materials are conducive to principles of true energy conservation, and eliminate the engineering gimmickry that plagues the building industry today. There is a sound strategy and an established method in masonry construction, both above and below grade. Low-tech, local, and on-site building techniques are tried and true. They have worked for thousands of years, and are very forgiving. Stone masons know their trade perhaps better than any other tradesmen, and the material is very rarely used incorrectly.

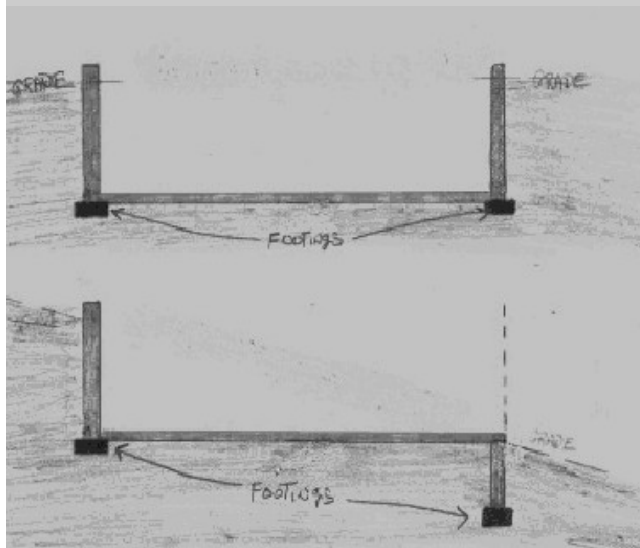
When thermally insulated on the outside with rigid insulation, masonry is once again one of the most cost effective building materials that we have. Material that is used correctly is not expensive, and the commercial type construction that is presented in [The Perfect Wall](#) is the best choice in buildings that rely on solar radiation, earth sheltering, and solid principles of energy conservation.

The migration of moisture is one of the most creative processes on the planet in terms of its energy transfer potential. The water molecule is omnipresent, omnipotent, and omniscient. It is unstoppable. Whenever and wherever we attempt to oppose it's natural properties, we will lose, and badly. When we create situations in which the water molecule has "gone wrong", we create big problems for ourselves. Consider, for example, resealable and air tight cereal packaging. Open one and add 1/4 cup of water to the contents, reseal it, leave it, come back next month and check to see what has happened. What we have done here pretty closely resembles what is often done in the modern building enclosure or environmental separator. To save energy, building components are often built too tightly. To save material costs, they often contain the same kinds of carbohydrates as corn syrup cereal sugarcoating.

In other words, the moisture and mold problems that occur in houses being built today arises from the fact that houses are not designed by physicists that want things to work, but by those that want things to be salable and profitable. The automobile industry has the same history, and required the import of Japanese technology in the 1970's. Today, it is the fast food and housing industry. Both cases call for recognizing that the problem begins with the ingredients. The deeper truth calls for recognition that the problem begins when profit is the main ingredient and determinant of purpose and lifestyle.

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FOUNDATIONS OF CONSERVATION



The foundation of a building transmits the weight of a structure to the earth that contacts the bottom of it's footings. A freeze at this surface will cause a vertical displacement that can destroy the building, so this must be set below the frost-line. In New England, the minimum footing depth was 3 feet, and this was often increased to 8 feet. Before the era of refrigeration, these "cold cellars" were often used for food storage.

Besides supporting the structure, the foundation was often designed to act as a retaining wall which acted to change the grade line around the building. Daylight foundations are three sided

foundations that provide for both day-lighting and on-grade access to the interior. In this way basement space can be upgraded to living space.

Of all the lines of a building, the grade line [the line of a house coming out of the ground] is the most important. Besides diverting water away from the base of a building, it divides the structure into two parts, one that interfaces with the earth and one that interfaces with the atmosphere.

<Figure 2>

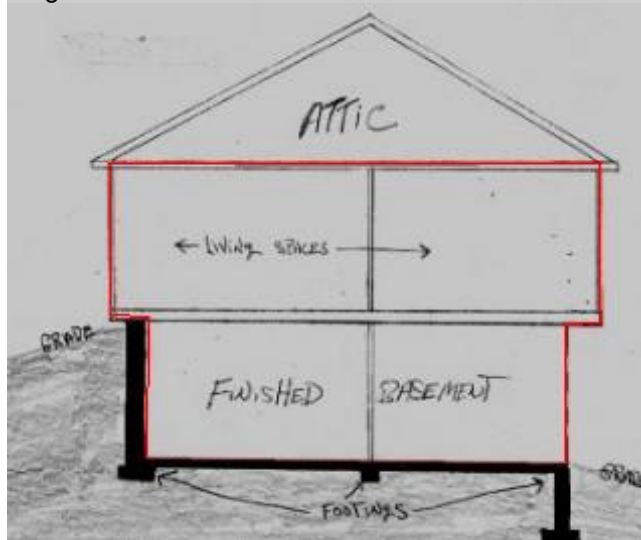
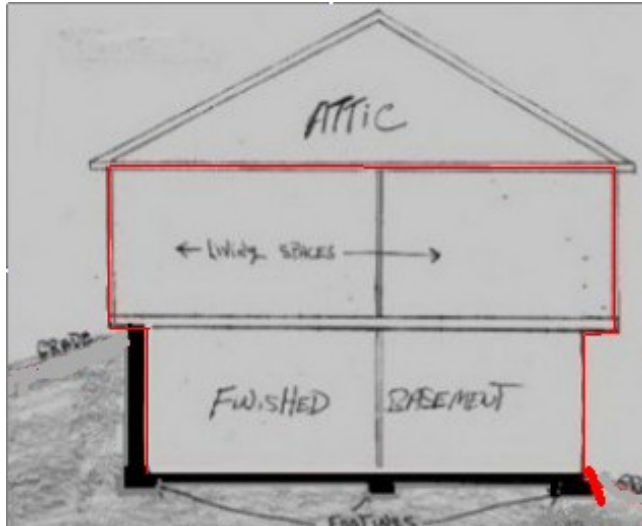


Figure 2 shows a typical 1960's single story home with finished basement. The red line indicates the [Building Envelope](#) which was primarily a thermal barrier between the interior and the exterior.

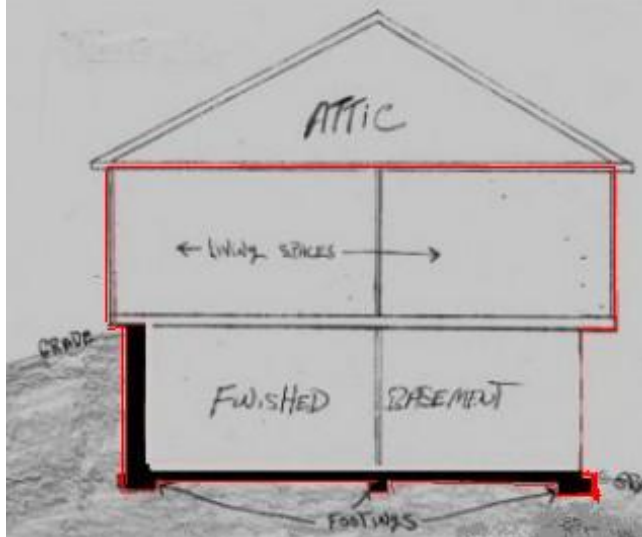
Conditioning in this era was limited to heating, and since the earth and the winter atmosphere were both colder than the living space, they were both left "outside". Usually, a basement was finished by building a framed wall inside the foundation wall, and then insulating it with fiberglass just like the exterior walls. The strategy of the building envelope was to thermally isolate the inside from the outside.

<Figure 3>



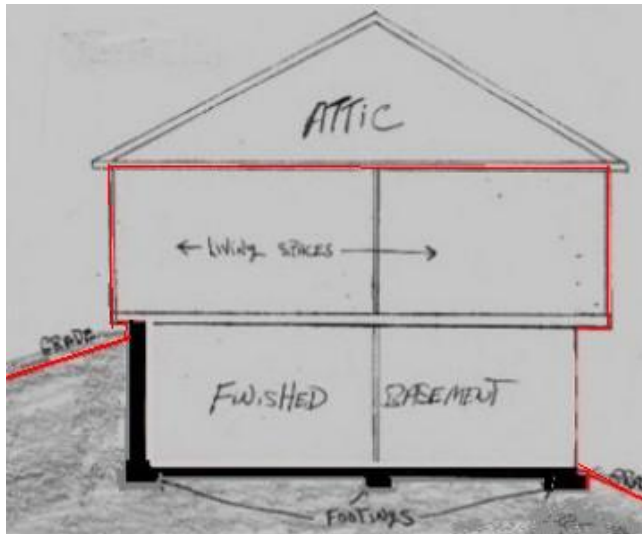
Gradually, it became evident that heat loss through the floor was preventing the footings from freezing. This meant that footings did not need to be placed as deeply below grade. Insulation placed outside the footings [heavy red] added more protection against the winter atmosphere by keeping them dry and warm, and [FPSF](#) evolved. Additionally Air conditioning loads were found to be greater than heating loads, but basement space requires less cooling because it "sees" earth rather than atmosphere. Figure 3.

<Figure 4>



Attempts to harness solar energy in the 1980's led us to rediscover the value of thermal mass in buildings. Insulation was moved from the inside, to the outside of the foundation wall. The foundation was now a part of the interior living space, as shown in Figure 4. This changed the thermal geometry of the building. We also found that we could control the moisture content and temperature of the soil by controlling the conditions of the interface between soil and atmosphere. Soil conditions are a dependent variable

<Figure 5>



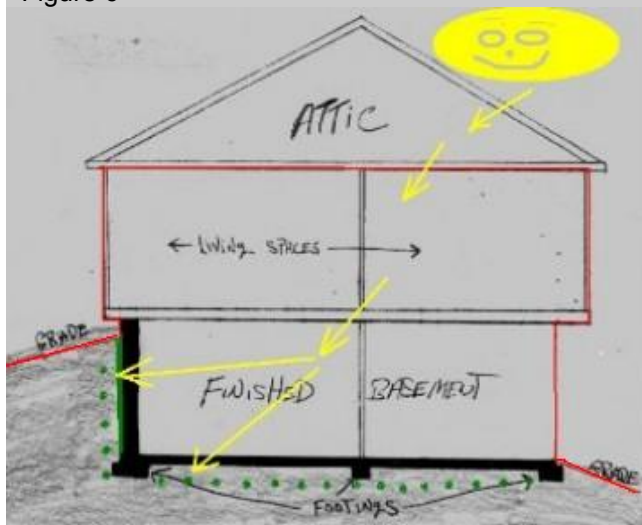
At some point, the thermal barrier was again moved further away from the foundation. The red line in Figure 5 shows this "Wing-line" insulation which prevents the transfer of both heat and moisture between the soil and the atmosphere.

The masonry foundation is now a thermal pathway between the living space and the soil. Both together form a heat sink or thermal reservoir that can absorb excess heat from the living space, while remaining isolated from the atmosphere.

This wing line insulation forms a shoreline around a thermal lake, or contained mass that is isolated from the atmosphere. Its temperature is now dependent on the heat flow through the

foundation wall. Some form of thermal bridging here will increase the amount of energy that can sink into the earth. This process will keep us, and our vegetables cool during the long hot summer, and the byproduct of this process will be an increase in the thermal energy of our reservoir that we can draw upon next winter. We might expect a 2-3 year "charge time", similar to the fill time of a lake, after which the entire mass will have reached thermal equilibrium.

<Figure 6>



Summer is a time of excess thermal energy. This process of solar flood prevention will store and conserve excess energy exactly as a dam stores and conserves excess water during the rainy season. In this way, we can reclaim the benefits of our chill-of-the-earth cold cellar.

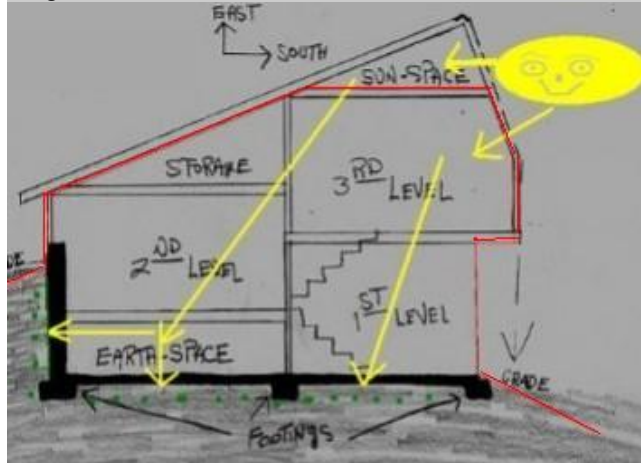
The Green area in figure 6 indicates the location of the thermal bridging that will facilitate this strategy. This interface must transfer both heat and moisture. It must deal with both sensible and latent heat of enthalpy.

The evolution of this transfer mechanism is indeed the point at which the rubber meets the road. Energy moves water, and water moves energy. They are working elements of the same

distribution system. Masonry is a material that will store and diffuse both.

Because of its physical properties, the material is the mechanism. Masonry will distribute both heat and moisture, in a manner that tends towards final state conditions that are optimal to the conservation of living space conditions that we wish to maintain.

<Figure 7>



The house in Figure 7 is built upon the same standard three-function foundation that has been described throughout. Since we have improved our technique of outflowing energy through the foundation [Green], we can modify the above grade portion of the building to maximize its solar gain. We want to collect as much energy as we are able to either use immediately, or dump into storage. We want zero remainders, which means no overheating, and no excess moisture. Of the two, the earth sheltering is more important than the solar aspect, but together they rule.

The transitions described in this section are simple building modifications. Attic has been upgraded to collect solar energy. Foundation has been upgraded to allow heat energy to flow into the earth. This is what happens naturally, and we simply quit trying to prevent it.

These simple extensions of functionality, upgrade what was previously an environmentally isolated building into an environmentally interactive building. The building is now the active interface between earth and fire that manages the flow of solar energy exactly as a dam manages the flow of the river. This configuration will prevent overheating during the summer months by diverting excessive thermal energy into the surrounding soil where it will remain available for later use.

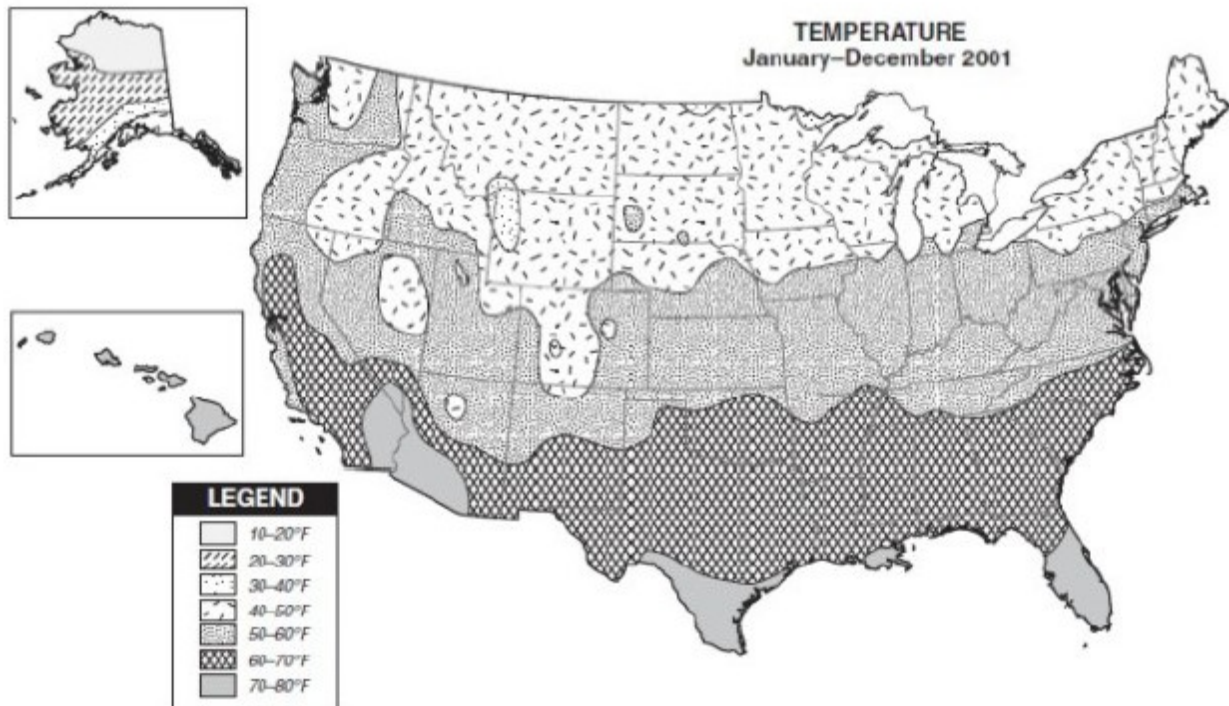
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EARTH SHELTERING

There is nothing new in the idea of earth sheltering. Early man took shelter in caves to avoid the even harsher conditions of the atmosphere. By doing so, he avoided wind, rain, storm, heat, cold, and other relatively more dangerous conditions that prevail above grade. Today the atmosphere is just as wild as ever, and still the only true culprit in the high cost of heating and cooling.

The map below shows the Average Annual Air Temperature for different areas in the USA. While the average temperature seems fairly innocuous, the variation from this average is not. Air temperature at a given location varies over a range of about 100° F, and is almost always far removed from the zone of human comfort which is right around [72°F, +/- 6°F]. The naked house gets very hot and very cold at

different times of the year, and requires great loads of energy to be happy. Placing a blanket of earth around the structure insulates it from the air, and protects it from moisture, wind, ultraviolet radiation, noise, drive by shootings, and other unforeseen atmospheric hostilities.

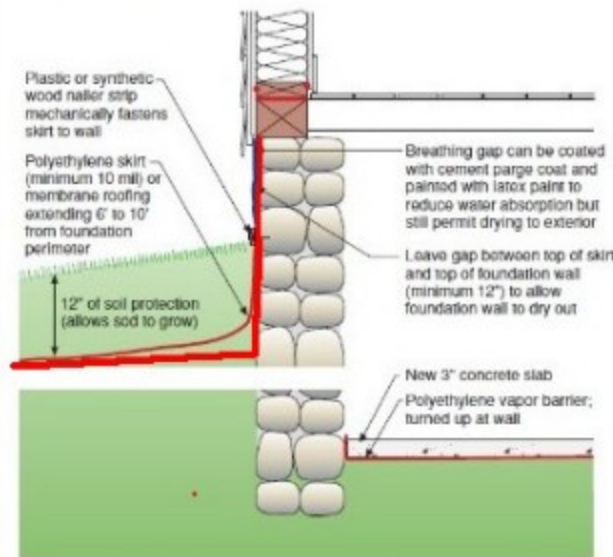


If we could hold the temperature and moisture content of the air to its annual average, buildings would use very little energy in remaining comfortable throughout the year. While that is not possible in the atmosphere, that is exactly what the soil does. Soil temperatures remain very close to the AAAT, and vary from that average by only a few degrees. A well constructed basement space, protected by its surrounding earth, stays cooler, quieter, safer, and more secure than its above grade, atmospheric component.

Figure 16

Using an impermeable skirt outside

Using an impermeable skirt outside of the home prevents saturation of ground adjacent to existing foundation.



We can further protect our surrounding soil from these same atmospheric hostilities. By placing a water/heat barrier at or near the surface, soil conditions become independent of atmospheric conditions. We can keep the soil around a building warm and dry.

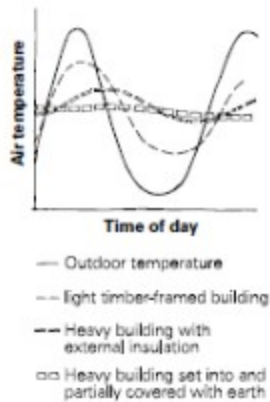
Some form of synthetic [Turf](#) can be easily installed on top of existing ground or grass. Such systems will support both the diversion and collection of water, and storage of thermal energy.

In doing this, we have moved the structure away from the atmosphere, and reduced the environmental pressure on it. This reduces maintenance costs, heating and cooling costs, and extends the life of the building. This will reduce the building's environmental impact. The less energy we burn, the less we pollute.

While we seem to be talking about conserving resources, environmental protection may be the real topic. When we disconnect soil from atmosphere, and then connect our buildings to the better behaved properties of this created environment we are talking about protecting a created environment. By protecting the environment, we are able to conserve resources. This reiterates an earlier statement that resource conservation and environmental protection are equivalent practices.

This does not mean moving our buildings underground. It means constructing buildings that interact with our environment in accordance to the same conservation principles. Earth is the conservatory of conditions that maintain life. Buildings should be simple extensions of these same environmental processes. They should be environmentally interactive structures.

<Figure 11>



Thermal mass is particularly beneficial where there is a big difference between day and night outdoor temperatures.

Correct use of thermal mass can delay heat flow through the building envelope by as much as 10 to 12 hours producing a warmer house at night in winter and a cooler house during the day in summer.

A high mass building needs to gain or lose a large amount of energy to change its internal temperature, whereas a lightweight building requires only a small energy gain or loss.

Figure 11 shows the variation in outside air temperature of a building over a 24 hour period, and how thermal mass and earth sheltering dampen that variation. This is important in a world of buildings in which the heating and the cooling system are often both activated within the same 24 hour period. Even in the spring or fall when the outside temperature might average 75°F, the heater might run in the morning and the AC in the afternoon. No Good!

Besides limiting temperature variation, and holding temperature close to its average over the period, thermal mass introduces a time-lag or phase-shift into the geometry of a thermal system. Peaks and troughs are increasingly diminished in amplitude and delayed in time as more mass is added. Peaks shift downward and to the right, while troughs shift upwards to the right.

The damping effect of earth sheltering on daily temperature fluctuation repeats itself over the annual cycle, where it is even more to our advantage. Here too, the extreme highs and lows of the atmosphere are clipped off, or averaged out, or distributed over time, depending on our choice of words. .

The same strategy of long term averaging that maintains the public water supply can be used to conserve thermal energy in home-grown buildings. The difference is that the former is a far off public works project, while the latter is on-site.

In considering the ways that a structure might interact with its environment, think about a tree which has branches and leaves above grade, and roots and feeders below grade.

Think about how a tree converts sunshine into biomass, and how it transports water, carbon, and oxygen. Think about how it "lives" within its natural environment. A tree as a thermodynamic device that converts and exchanges both energy and mass with its surroundings, according to the 2nd law, entropy, and enthalpy. This is the level at which we must think about constructing buildings that are environmentally interactive. We must think very deeply about some very basic science. In doing this we will learn much about how to construct buildings, and much about the Nature of our planet. We may yet cease to be the most invasive and alien species on Earth.

There are two solar cycles on our planet. One is the 24 hour day/night cycle that repeats itself on each revolution of the planet. The other is the yearly cycle that occurs as the earth circles the sun. In this annual cycle, the temperature of the soil has time to attain a temperature that is very stable and very close to the average air temperature. Soil temperatures on this scale can be of great benefit to buildings.

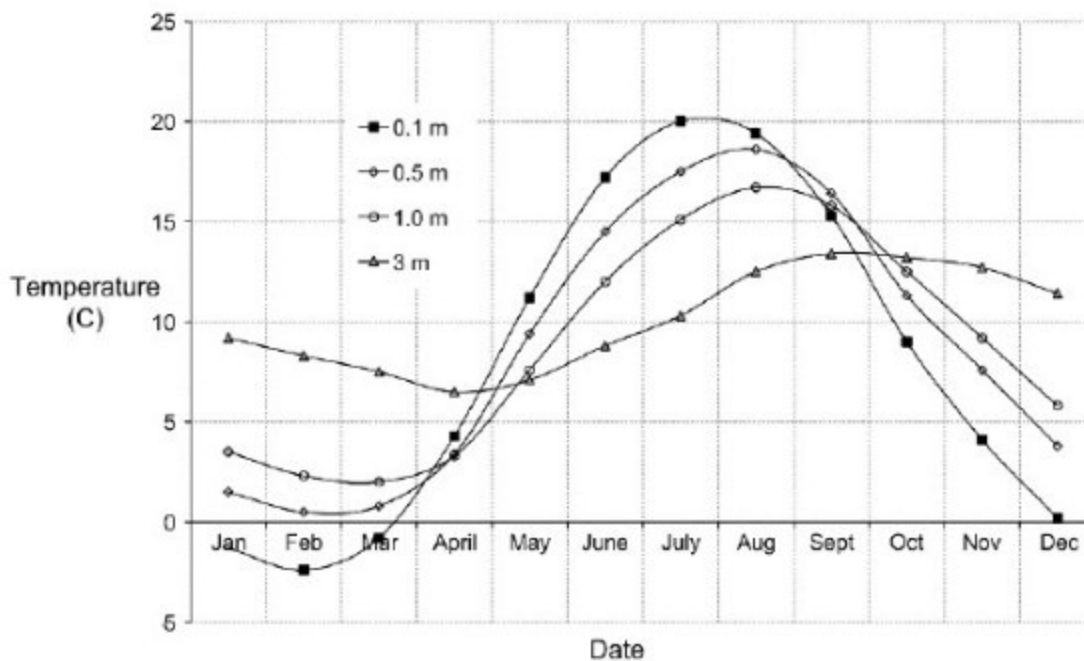
In traditional building design theory, the soil surrounding a structure is considered to be outside the building envelope. As part of the exterior environment, its thermal effects on the building are small but well documented. The first thing to be seen is that earth is a much less hostile environment than atmosphere. This is the first important fact when considering earth sheltered structures.

<Figure 12>

Heat Loss to the Ground

The ground temperature under and next to a building is generally very close to the annual average temperature. This means that the temperature difference between the inside of most buildings and the ground is not that large, although it is much steadier. Hence, less insulation is needed to control heat flow to or from the ground.

Nevertheless, some insulation is still required in many climates zones (DOE Zones 3 and higher). In many cases, heat flow control for slabs, crawlspaces, and basements is limited by that needed for control of moisture and comfort problems, not energy.



Temperature profile through the ground over the year in a cold climate location

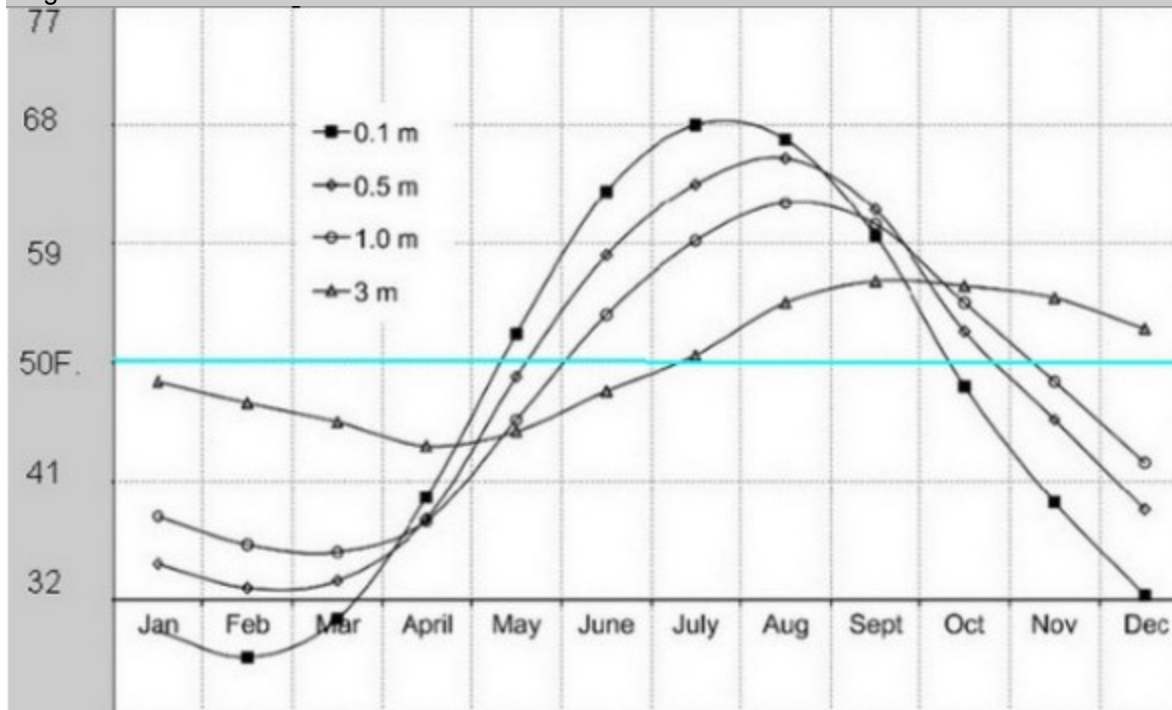
The information in <Figure 12> above comes from [BSD-011 Thermal Control in Buildings](#). It can be found at [Building Science Corporation](#) which is an excellent source of information for the homeowner. We will look at the data that has been collected under the previous paradigm to see what meaning that will bring to our new theory. Facts are relevant to the system of thought in which they occur, and we are establishing entirely new context.

In our new design theory, earth is a part of the thermal mass of the structure, and therefore part of the interior environment of the building. As such, this heat loss to the ground is now to be thought of as heat distributed into thermal mass. In the new theory this is an asset rather than a liability. It is this distribution that prevents both summertime excess and wintertime shortages. Some may find it more sensible to use water stored in fiberglass tanks around the structure as the thermal storage medium. This alternative may facilitate the transfer of thermal energy back and forth between storage and living space. This approach would work well with ground source heat pumps, and also lend itself to adding external solar heat sources as in Drawing 1. The decision to insulate these tanks or not will be an interesting challenge in the process of optimization. Certainly that will depend on local conditions of soil and environment.

Figure 12 above shows soil temperatures at increasing depth around a building foundation. Since most Americans have a better feel for the Fahrenheit temperature scale, we are going to convert this graph from Celsius to Fahrenheit with the formula ($F = 9/5C + 32$).

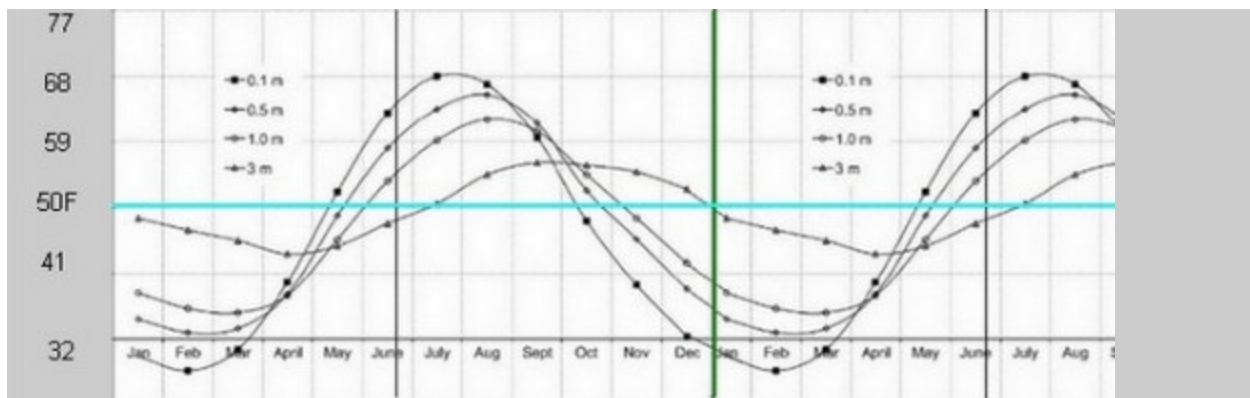
Figure 13 below is the same as Figure 12 above except that the temperature scale has been converted from the Celsius to the Fahrenheit scale. The average temperature for the period is shown by the chartreuse line.

<Figure 13>



Next we are going to line the graph up behind itself so that we can better see how the yearly cycle repeats itself. Figure 14 shows temperature variation from June 21st, to the following June 21st.

<Figure 14>



Finally, we are going to add some color so as to highlight the patterns that are contained. Figure 15 is just a colored version of Figure 14. The colors may point to the patterns.

<Figure 15>

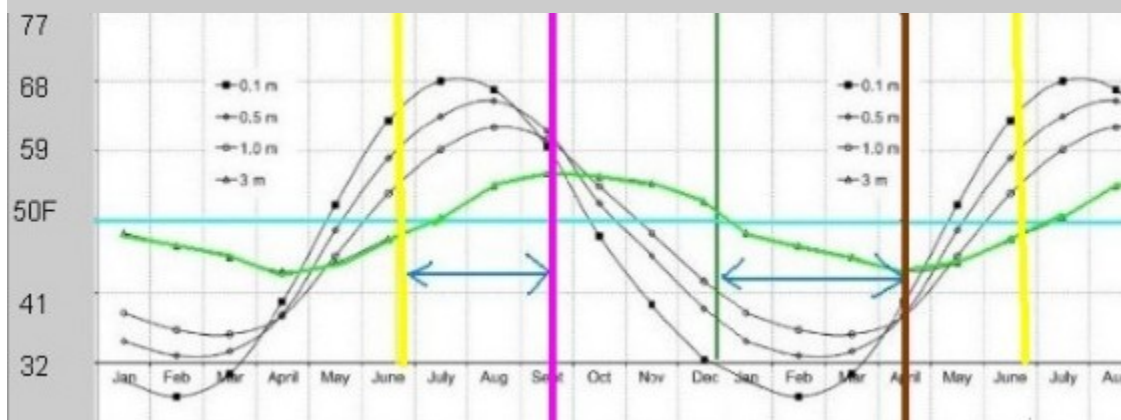


Figure 15 shows the variation in soil temperature at the four given depths indicated in the graph legend. The Green graph line shows the temperature at 3 meters or about 10 feet. This is the depth that most closely relates to earth sheltered structures, especially those that maintain a thermal/moisture barrier between the soil and atmosphere.

The two vertical Yellow lines [occurring at June 21-22] mark the summer solstice in two successive years. The vertical Green line marks the winter solstice that occurs around December 21st. The horizontal Chartreuse line marks the Annual Average Air temperature at this local. The two Horizontal Blue arrows <-----> show the Time-Lag that occurs at this depth. Summer insolation is greatest on June 22, but maximum soil temperature occurs around September 22. This is where the maximum value of the Graph is cut by the vertical Pink line. Likewise, while minimum solar insolation occurs around December 21, the minimum soil temp occurs in the middle of April where the Graph is cut by the vertical Brown line.

Note that with increasing depth there is an increase in both temperature stability and time-lag. While air temperatures at a given locale often fluctuate over a range of 100 degrees F, soil temperatures can vary by less than 10 degrees. Soil temperature at this locale and depth [about 9 feet] could also be expressed as $[50^{\circ}\text{F} \text{ plus or minus } 6]$, or as $[50^{\circ}\text{F} \pm 6]$. Humans are comfortable somewhere around $[72^{\circ}\text{F} \pm 6]$.

The graphs above display some pretty typical patterns: 1. Soil temperatures follow the Average Annual Air Temperature (AAAT) at a location; 2. Soil temperatures fluctuate much less than atmospheric temperatures; 3. Time-lag in soil temperature fluctuation is greater than the time-lag in air temperature fluctuation. This will prove most useful since the soil is both our dump and our source of thermal energy. We would like the soil temperature to be maximum during the winter months and minimum during the summer months. We will try to optimize this time-lag at six months which is equal to $1/2$ the period of the annual cycle.

Summertime is a time of solar flooding. We have prevented overheating within our homes by dumping this excess thermal energy into the soil around and beneath our homes. With the passage of summer, the foundation wall temperature has become pretty much the same as the inside basement temperature, and is no longer a condensing surface. The added potential energy that is contained in the increased temperature of our heat store is the byproduct of this passive cooling technique. We can expect an increase in energy content of our thermal storage during the summer months, exactly as we expect a rise in the water level in the reservoir above a dam during the rainy season

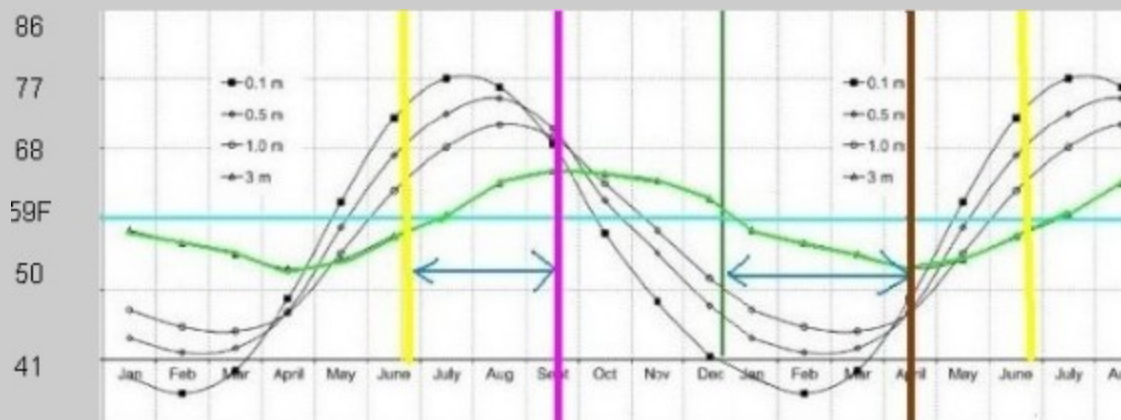
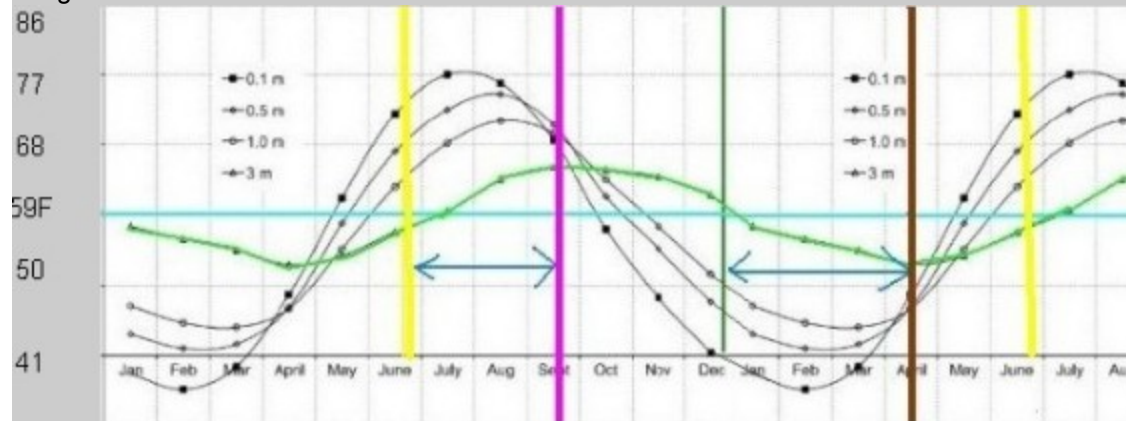


Figure 16 below is a replica of Figure 15, bumped up one notch. It is no more than a guess at how much heat might be stored in this manner. The old timers used to would say "there ain't no telling", which was a nice place to be because you knew then that you were dealing with possibilities and mystery and stuff not yet included in the engineering handbooks. Back in 1982, at the beginning of all this, a friend told me that the local thinking in Forsyth County centered on the idea of keeping "a small eternal flame" in order to add warmth and dryness to so called underground houses. Then too, somebody had finally built the first all glass skyscraper and won an award for that too, which is all real interesting. A key word back then was prototype, today it is paradigm. The big advantage today is the Internet which opens the possibility of sharing global as well as local experience. As mankind and climate both seem headed towards more turbulent times, some form of new beginning might become necessary. As in The Swiss Family Robinson, we might face an abrupt course change that turns up some totally new experience. Some might simply choose that course change.

<Figure 16>



If we managed to raise the temperature of our thermal reservoir by 9°F, we would be very close to the zone in which humans are comfortable. That might actually be too warm. We will find the ideal solutions for different regions by trial and error. In a later section, we are going to talk about ground coupling systems that will transfer heat back and forth between living space and thermal storage. These ground source heat-pump systems will be small back up units that will kick in after the limits of our passive techniques have been reached. Mechanical systems have the advantage of acting immediately and on-demand. Passive preconditioning systems will allow their downsizing and diminished energy use.

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PASSIVE CONDITIONING: ENTHALPY

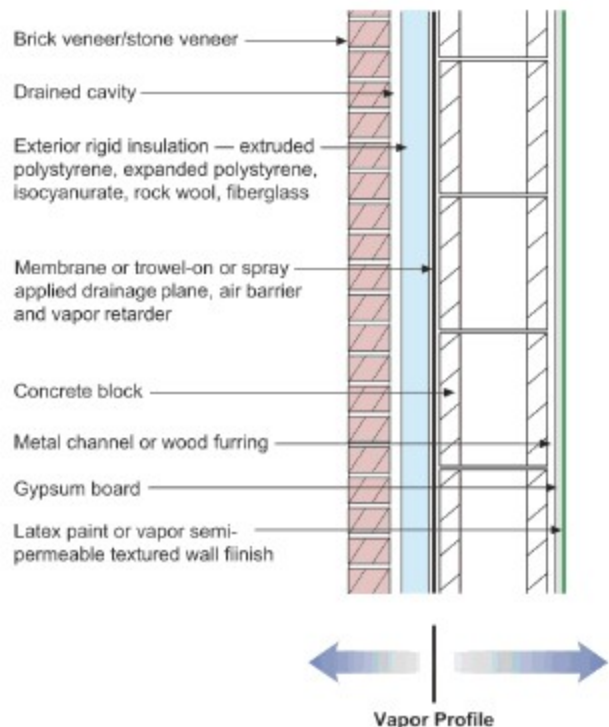


Figure 6: "The Institutional Wall"

The best wall that we know how to construct. Works everywhere in all climate zones.

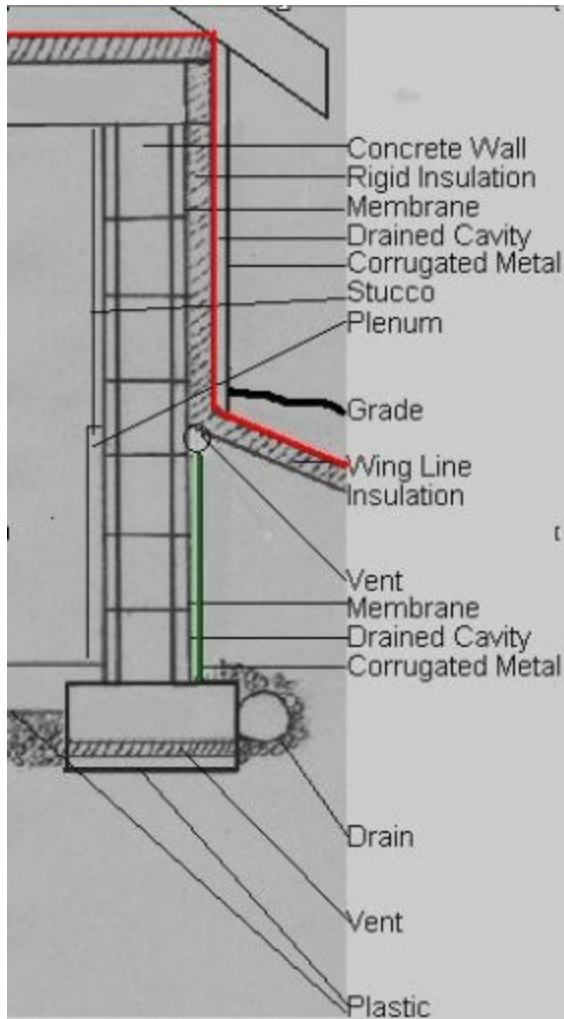
As a building material, masonry exhibits a unique combination of physical properties. According to www.buildingscience.com, this type of wall will work anywhere. The fail-safe qualities of this material as described on that site make the techniques, strategies, and applications suggested on this site possible. Without the information presented there, nothing here could be attempted.

We're going to take what was suggested as The Perfect Wall [[BSI-001](#)] and improve it. Above grade, we counted on the masonry wall: 1] to provide storage for both thermal energy and moisture, 2] to prevent the flow of thermal energy between the interior and the atmosphere, and 3] to allow "Flow Through Drying" to both the inside and outside in order to prevent the accumulation of water inside the enclosure.

Below grade, we want our wall to do something quite different than it does above grade. We wish to tailor the wall to each of the two distinct environments. Above grade, the wall is insulated from the atmosphere on the outside with Styrofoam as shown in Figure 8 below. At the

grade line this insulating blanket turns outwards, and runs along the ground surface where it serves as a thermal and water barrier between the atmosphere and the soil. This interface can be some form of [Synthetic Turf](#) that is easily installed on top of existing grade. Such barriers will manage the collection and storage of water as well as energy. Water in the coming years is going to become even more precious than energy. Additionally, it seems that [grass](#) is getting more difficult and less wonderful than it once was.

<Figure 8>



Below this barrier, the wall is bridged to the soil with fluted metal decking that contacts concrete and soil at their interface, and allows the concrete to "see" the soil better. This will increase the flow of heat into the soil, and cool the outside surface of the concrete. This will effectively increase the thermal gradient across the wall which will drive the flow of thermal energy and moisture through the wall. This configuration will diffuse both heat and moisture to the outside. It is a flow-through assembly that will dry and cool to the outside during the summer. This through-flow process will prevent the entrapment of both heat and moisture within the structure.

The fluted metal forms a drainage cavity between the wall and the soil that is part of a continuous vent assembly to the atmosphere. Two perforated pipes—the 4" drain pipe at the footing, and the 2" pipe above the metal—are open ended to the air. The drainage blanket beneath the slab is also vented via 2" pipes through the footing. Vent stacks may be added to insure that pressure is equalized everywhere.

In this way, we can direct the flow of thermal energy into storage in the same way that a dam directs the flow of the river into the reservoir. Solar flooding can be prevented exactly as flooding by water is prevented. Essentially this is an activity of both environmental protection and resource management. It will prevent the building from overheating during summer, and reduce need for mechanical air

conditioning.



Because of the greenhouse effect, any above grade structure is going to overheat in the summer atmosphere. An attic will be much hotter than a basement. Units pictured left pump this excess heat back into the summer atmosphere. This is a vicious circle which is equivalent to pumping excess water back upstream in order to prevent flooding.

Buildings create their own surrounding micro-climates, and [Waste Heat](#) is the byproduct of air conditioning. Collected micro-climates become [Urban Warming](#). I understand that this statement is a repeat.

Natural variation in both the water cycle and the solar cycle can be averaged together over a two or three year period, and this will eliminate both

surplus and shortage. Since all matter has thermal mass or heat capacity, thermal energy can be stored either directly in the soil, or in below grade water storage tanks.

The combination of these two approaches, passive preconditioning as in basement space, and ground source heat exchange, could greatly reduce the use of electricity. Buildings in rural areas can be built without the double trouble monsters pictured above. Electricity is one of the major players in climate disruption.

The main focus of this entire article is the analogy between what becomes of excess heat, and what becomes of excess water. In both cases, we can choose a strategy of conservation. While this approach may not be applicable in urban areas, its implementation in rural areas will lay out land usage requirements that will prevent further urbanization. Much of this discussion is a matter of choosing a rural rather than urban lifestyle.

The flow charts of these two approaches to the problem of solar flooding are as follows:

Evidently, our new approach is a conservative process that will achieve a final, equilibrium, or limit state condition somewhere close to what Goldilocks finds to be "Just Right". Energy may be "added into the system", if necessary, during the summer months via a separate solar application.

Additionally, we have effectively moved the environmental separator or building enclosure away from the structure. This will greatly reduce the maintenance needs and increase the life expectancy of the foundation wall by protecting it from the environment. Assuming the foundation is not located in a swamp or below the water table, it will remain intact for a very long time.

We have created a "Thermal reservoir" which serves as a buffer between the interior living space and the atmosphere. It serves as both a heat sink and a heat source. Later, we will consider methods of "Time Lagging" in order to achieve a six month [1/2 cycle] phase shift. We would like the temperature [energy

content] of this thermal lake to be maximum in winter, and minimum in summer. We are in the early days of possibilities.

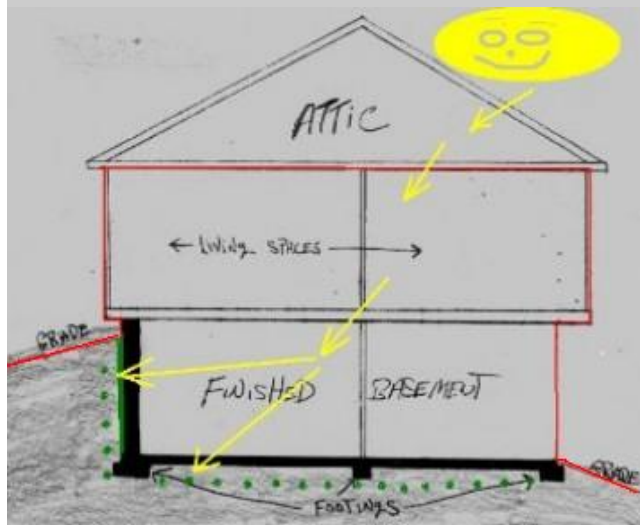
Essentially there are three important aspects of earth sheltering. First, earth is used as an insulating blanket between the structure and the atmosphere, as in earth-berm houses. Second, the passive modulating effect of thermal mass stabilizes interior temperature swings. These two effects are commonly embedded in current state of the art buildings.

The third aspect, that of managing thermal energy as a commodity similar to water is the least known and most exciting possibility that lies before us. It is accomplished simply by relocating insulation, and will pay for itself immediately by preventing summertime overheating, and reducing our dependence on air conditioning. Any further gains beyond this are gifts.

Methods of enhancing heat exchange through the foundation wall will evolve locally and specifically, just as is the case with backyard gardening. Eventually, or alternatively, the system might be brought into balance without the heat pump. Local intelligence will again order the nature of reality. Some things cannot be purchased from far away. They must be built locally.

In summary, diffusion of excess heat and moisture to the outside will insure that both the sensible and the latent heat of enthalpy will be moved out of the interior. Solid masonry walls prevent moisture entrapment within hollow building enclosures. Because this wall is adapted specifically to each of the two distinct environments, it will be a little closer to perfect.

Understanding the full potentiality of the earth sheltering process will coincide with the evolution of energy transfer mechanisms. Distribution of energy between living space and thermal mass is where the rubber meets the road so to speak. The combination of thermal pathway plus diffusing air gap is a thermal distribution mechanism that may bring us one step closer to the realization of optimal energy transfer mechanisms.



Many homes today are sold with unfinished basements. Until insulated, heat is going to flow through the foundation walls into the soil, and they will function exactly like the earth sheltered space described above.

The simple claim is that insulating basement walls will increase the annual energy costs for heating and cooling, and should be avoided. Thermal-moisture barriers should instead be placed on top of the ground surrounding the structure.

Enhancing the thermal connection between the structure and the earth, while insulating both

from the atmosphere is the most efficient way to interact with our environment.

Furthermore, we can optimize this environmental interaction by reintroducing the passive techniques that were previously abandoned. In this way our electrically driven systems can be downsized to backup systems. Reintroducing the masonry building products of previous times that are moisture tolerant, durable, widely available and well understood to provide both thermal and moisture storage capacity will also eliminate the problems we have created by using less durable building materials.

In summary, there are three important aspects of earth sheltering, namely that: 1. Soil can be used as an insulating blanket to prevent heat flow between building and air. 2. Soil can become part of the thermal mass of a building, to limit temperature variation. 3. Soil is an effective thermal reservoir. It is both a heat sink and a heat source.

The last of these is the most important. By closely tracking the Average Annual Air Temperature, it provides the possibility of establishing thermal equilibrium at something very close to the human "comfort zone". That could occur in a building that maintained an interior temperature of about 10°F above the AAAT.

Also, the stress levels that soil places on the exterior surface of a building are much less than the stress levels of the atmosphere. Reduced stress means reduced maintenance and greater life span. In short, we have moved the thermal and moisture "boundary" away from the house wall. This distributes the gradient over a greater distance, and constructs it from soil which is highly durable and inert. We have reconfigured the interface between our interior living space and the exterior climate.

Additionally, we have suggested the possibility of using fluted metal cladding as a thermal bridge between a below grade foundation wall and the soil. This could enhance the passive exchange of both heat and moisture by forming a natural condensing surface. When we emulate nature we promote homeostasis of both the interior and exterior environment.

Finally, we suggested that a ground source heat pump might move heat at a fraction of the cost of generating heat. The distribution of energy back and forth between our "living space" and heat sink is the fulcrum point of the discussion. Energy that was previously wasted to overheating will be "added into" the total energy that is available to us over an extended period. We will have balanced deficits and surpluses exactly as we do with water, or any other commodity.

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MOISTURE AND RELATED TECHNOLOGIES

The design of buildings is only a part of the plan. In all areas, we can learn to "think upstream", and gracefully accept the gifts that are bestowed on us. We can forget all of the marketing gimmickry and get back to real conservation. This does not mean contracting our economy, it just means interacting with our environment rather than opposing it. It means establishing a healthy and symbiotic mentality, rather than a parasitic attitude. Enough is enough!

Condensation, distillation, and evaporation are processes of critical importance throughout the world. We are intensely interested in finding ways to promote these processes at times, and to prevent them at

others. We wish to be able to manage when and where they occur, because water in all its forms and movements is even more precious than energy.

Much of what we must learn is already known. Water and energy have been a vital concern throughout history. Looking from the outside in, at previous efforts such as air, or [Air Well Discussions](#), or [OPUR](#), or [Solar Still](#), informs us that our interest in resource conserving structures is a only small piece of the picture..

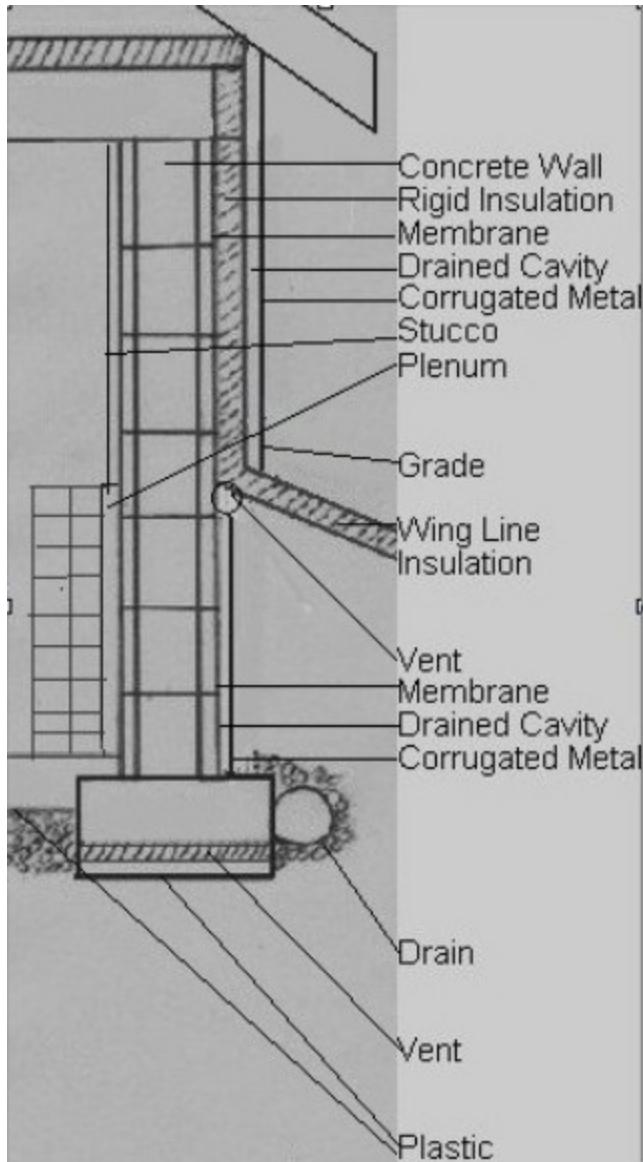
Humans are comfortable in buildings that maintain air temperatures around 72°F, and humidity levels around 50%. Modern Air conditioning systems perform both cooling and dehumidification. We have been OK with this because we have had plenty of electricity, and we never really see how inefficient it is to do both together. Single function devices with dedicated controls are more efficient, and they allow us to see exactly what costs what. They are more reliable, durable, and simpler.

For heating and cooling, a small ground source heat pump will efficiently move thermal energy back and forth between living space and thermal storage. Mechanical systems have the advantage of providing immediate, on-demand heating and cooling. Passive systems do not require energy input, but they work slowly over time. Some combination of both will provide the greatest comfort at the least cost. A small back-up system that is activated only after the limits of passive control have been reached, will provide every comfort we now enjoy.

The situation with moisture is the same, and we will use small mechanical back up systems that engage only as needed. Moisture control is not on the critical building path of the structure. It can be installed as an add-on after the building is occupied, and this greatly increases the opportunity to experiment with non-mechanical approaches. As with heating and cooling, the idea is to employ passive devices that precondition interior climate, and then to use active systems as needed.

[Desiccant humidity control](#) is one of several approaches. The hygrothermal region in which the building is located will be a major influence. The important thing is that any mechanical device should be controlled by a humidistat. This dedicated control device removes both the mystery and the inefficiency of moisture control. This provides real-time feedback to the building supervisor in his attempts to explore passive methods of preconditioning that will prevent activation of the device.

<Figure 8, Again>



Dry [Calcium Chloride](#) or "road salt", gives off heat when it gets wet, and is used to melt ice on the highways. It soaks up water, and gives off heat. It also absorbs moisture from the air, and can be used as a desiccant. It can be regenerated [dried out] by evaporating the water from it. We will use our sun-space to regenerate the material. It is safe to humans and plants, and is used to dry and preserve foods. It is corrosive to concrete and metal, so we'll use plastic surfaces to contain it.

Desiccant salts were commonly used before air conditioning. Because they are widely used in drying processes and packaging, they are again available in many convenient forms, but more importantly, salts are naturally and freely available to the people. They are non-propitiatory, and inexpensive.

To absorb moisture from the interior air, place the desiccant very close to the inside surface of the concrete wall and then circulate the air over it.. As the desiccant picks up moisture from the air, it will become warm and moist, and finally attain a liquid state.

Heat energy will flow into the concrete, while the spent solution will flow into a catch basin to be returned to the sun space for regeneration. This process will cool and dry the air. It is only one of many approaches.

Another would be to precondition the recovery or make-up air in the same way. This too would protect the interior climate. In all cases, we are allowing energy to flow along it's own natural gradient, which requires no energy input.

Rather than inventing anything new, we are simply replicating the creation processes by

which Planet Earth eternally renews itself. Condensation, evaporation, distribution, and reservoir, are naturally occurring events.

Air can be passed over common, solid desiccants (like [silica gel](#) or [zeolites](#)) to draw moisture from the air to allow an efficient evaporative cooling cycle. The desiccant is then regenerated by using [solar thermal energy](#) to dry it out, in a cost-effective, low-energy-consumption, continuously-repeating cycle.

Another approach would be to construct the plenum using unfired brick, adobe, or other material which will absorb moisture from the interior air. Such materials are hygroscopic and serve as reservoirs that store and release moisture as well as heat. They can be stacked inside the foundation wall, or applied as a stucco finish.

As before, this will be a part of the interior air circulation system that will distribute heat and moisture to the masonry wall as part of the passive heating and moisture control systems of the structure. It will also provide a chase for electrical wiring and outlets, and plumbing. In certain cases, additional water pipes might be installed in order to distribute solar heated water for radiant heating.

These passive processes of heat and moisture transfer are not recent inventions. They are nothing more than the processes of condensation and evaporation that occur naturally on Planet Earth. They were used in homes before being replaced by mechanical systems of cooling and dehumidification. But this need not be an either/or situation. We can use passive and active systems together.

An "environmentally interactive structure" is neither a paradigm nor a prototype. It is merely a mechanism that copies natural process. We have a sufficient knowledge of materials to replicate these processes at the local, on-site level. Both the materials and the necessary skills are available for us to replace ancient sunshine with original sunshine. We can do this today, and from now on.

Scarcity of energy and water lies in the future that we have created. The design of our buildings plays its part in that. To mitigate this we must design buildings that conserve and protect their exterior, as well as their interior environment. Actually, that turns out to be a concurrent event. We can design buildings that conserve rather than consume the natural resources of our planet by obeying physics instead of economics. This will create our most cost effective future.

We're also going to look at other processes such as condensation, distillation and evaporation, and apply that knowledge to the design and construction of buildings. By replicating the thermodynamic processes of our planet, we can cooperate rather than oppose nature. Opposition to nature is a zero sum game.

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SUNLIGHT

When a healthy man has had enough to eat and drink, he leaves the table. The lack of this sense of sufficiency has much to do with addiction, dependency, and mental disorder of the kind that ravages our world today. Without this sense, a man is forever impoverished.

Real and concrete feelings are the focal point of human experience, and the real site of knowing. The meaning and significance of life, and the sense of being alive, are located here, and one must hold to this center. A wealthy man is one who knows that he has enough.



Our species may have outwitted itself by seeking other than this. In assigning value to things other than what can be experienced in this manner, we seek that which is insatiable. In letting go of this holding to the center, we may have lost the organizational principle that is essential to our continuation.

The true value of living within the means of what our natural world provides, may be in preventing the loss of this experiential center. Without this consciousness, our species may be pumped for profit, and completely misdirected.

Change in our current course for whatever reason, might well bring us back to an agrarian society. Despite its difficulties, this lifestyle would provide for the base line survival of our species, as well as the sustainability of our planet's environment. It would conserve our species and our environment indefinitely. It would require nothing more than on-site technology, and it would provide complete autonomy, independence, and self-sufficiency.

It would require [Low Temperature Thermal Energy](#) which is the direct conversion of sunlight into heat. This is the practical, natural, and fail-safe approach that, along with photosynthesis, has sustained life on our planet throughout the ages. It is the hands-on, low-tech approach that belongs to the people.

There is much talk about high-temperature solar thermal energy, and also about photovoltaic conversion of sunlight into electricity. This is the most costly and least efficient. Both of these alternatives might provide clean energy, but that would still be delivered across the existing grid, which will always be prone

to failure. Furthermore this still forces the people into the role of consumer rather than producer. Additionally, electricity, is the most wasteful form of energy.

To make a gallon of tea you can boil a gallon of water on a hot plate, add tea bags, and presto you have tea. Or you can add tea bags to cold water in a glass container, put it in the sunshine for several hours, and have tea for dinner. The source and form of the required energy could be today's sunshine, or ancient sunshine in the form of coal which drives a steam turbine and generates today's electricity. It is simply a matter of choice, although the determinants of that choice might be very complex, and include such factors as time, convenience, habit, attitude, location, weather, byproducts, cost, availability, and so on.

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SOLAR-ASSISTED HYBRID: 1982

The house pictured below was the first of three prototype homes that were built in the North Georgia mountains during the 1980's. It was built near Haw Creek Road in Forsyth County, Georgia in 1982. There was no way of knowing back then how well the house would work, so the primary objective was to make it aesthetically pleasing to live in. The house is best described as a solar-assisted and earth-sheltered hybrid. The critical element in energy conservation is thermal mass or thermal storage capacity. Thermal contact with the earth seemed the only feasible way to prevent overheating. In retrospect the structure seems rather ungainly, but that is what was being done in those days, and it's hard not to get caught up in the times that you are in.



This is the south facing side of the house. The kitchen and living room occupied the first floor. The 300 square feet of glazing on the roof served the isolated gain sun-space which was the main solar component. The glazing on the first and third floors was designed to be interchangeable with wood panels. This introduced a fudge factor to help optimize the final amount of glazing that was used.



The floor was Mexican tile over concrete which was insulated underneath with Styrofoam. 300 lineal feet of 3/4 inch galvanized pipe was installed beneath that, and around the foundation. This was an element of the transfer system designed to carry thermal energy into the earth.



The far wall is the interior surface of the concrete foundation. It was finished by applying a layer of latex stucco, colored Antique White by adding a bit of black and yellow latex paint, directly to the masonry. This is a nice way to finish a block or concrete wall, because it allows the wall to breath, which is essential. It is also a way to cover blemishes in the concrete. Most importantly, it eliminates a cavity in an exterior wall which too often entraps moisture. This is especially important above grade where thermal and moisture differences between the inside and the outside are greatest. The wall is insulated on the outside with rigid insulation.

Warm air from the sun-space was first circulated through the earth-space [located to the left and behind the wood stove] which absorbed heat energy before returning it through the living space to the sun-space. This recurrent process distributed thermal energy into the surrounding earth , and prevented the house from overheating during the daytime.







On the second level, cedar walls covered the foundation. This allowed airflow over the foundation wall as part of the passive cooling system. It also creates a chase for electrical wiring and outlets. Finally, it could form a crib in which to place a desiccant material used in dehumidification.



The plank to the doorway is in lieu of the proposed screened porch.



Looking west through the sun-space. The shadows indicate that it is about 9 AM on a partially sunny day in either November or January. In December the shadows penetrate more deeply towards the back of the space. A better guess could be made if the picture had been taken at solar noon.

Sunlight intensity can be estimated by observing the sharpness of its shadow. Full sunshine will cast a sharp shadow. $\frac{3}{4}$ sunshine will cast a $\frac{3}{4}$ shadow. $\frac{1}{2}$ and $\frac{1}{4}$ sunshine will further reduce the sharpness of the shadow, Full cloud cover will eliminate shadow. It looks to me like this photo was taken at a moment of about $\frac{3}{4}$ full sunshine. A sun-space is not generally habitable, but occasionally provides exhilarating experiences.

On the wettest,, coldest and cloudiest winter days, the sun-space would always be at least 20 degrees warmer than the atmosphere, so even when not working well it was doing the right thing. When sunlight intensity was $\frac{1}{2}$ or better the temperature would reach 130 degrees between the hours of 10AM and 4Pm. During the summertime, the windows at both ends of the sun-space could be opened to create a chimney effect that would draw cooler air in through small windows on the north side of the house. The living space in summer would remain 20 degrees cooler than the outside air.



Exterior and Interior of house built in Deerwood subdivision.



There is nothing more pleasant, reassuring, enlightening, settling, comforting, nourishing, and peaceful than living in a house that itself lives in the present tense of today's sunshine. Father in Heaven provides, Mother Earth protects. If you have a dog or cat, [s]he will live "in trance" there. Because it follows sound energy conservation principles of physical law, it will remain cool and shady in summer and warm and toasty in winter. Because it is based upon a daily as well as a seasonal cycle of sunshine, one experiences a strong connection with nature. Three or more days of sunshine per week will prevent sunlight deficit disorder and give one a sense of energy sufficiency that is otherwise unavailable.



The third house was built in Dahlonega, GA. By then I had learned a more contemporary look.

A house should be built in the sunshine where it can stay warm.

It should be built into the earth where it can stay cool.

It should breathe in the air, transpire, and dry itself out.

It should direct the water that falls on it to a nearby tree or garden spot.

Both in taking of, and giving back, it should follow the way of nature.

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GRADIENTS

The concept of the gradient gives us insight into the properties of matter and energy in our world, and helps us to determine whether we are going with or against the flow of nature. In general, any potential difference can be represented by a gradient. Very often the mathematics of differences and ratios is much more important and interesting than the mathematics of sums and products. The former deals with comparisons, relationships, and connections, while the latter deals with collections and aggrandizement's.

We are interested in four of them which are pretty easy, so don't panic. Water runs downhill. Heat flows from hot to cold objects. Fluids flow from high to low pressure. Vapors diffuse from high to low concentrations, which is why we can smell perfume throughout the entire room. That's it! Consider these few examples which show their importance in the world in which we live and build houses.

As a balloon is blown up, the difference between its internal and external pressure increases until it pops. Until then, it is an environmental separator that preserves a pressure gradient across its boundary. This one directional case is much easier than in the exterior walls of buildings, where the high and low sides often switch back and forth. An ordinary house in an environment that varies between 80°F in summer, and -20°F in winter, is more difficult. This is the application that interests us most. To eliminate difficulties, we are going to use masonry building materials in both the above and below grade applications, and any insulation will be applied to the outside. This is the most fail-safe approach to residential construction.

Any energy gradient is just a difference in energy between two different points. Energy can take form in electric, pressure, temperature, chemical, potential or kinetic entities. To think of a home as dynamically relating to its environment, as a living organism, in the same sense as a tree or a hydroelectric dam does, is really not too surprising. Every living thing is an alimentary canal and a thermodynamic device because it exchanges both energy and matter with its environment. Much of what happens on Earth has to do with distribution processes and their representative gradients that help us to understand the dynamics of our everyday world.

There are times to increase the gradient across a boundary, and there are times to reduce it. An internal combustion has a compression ratio of about 12:1, and the greater that is, the greater the power output. But gradients must be managed intelligently, and there are times to reduce them. Nature has a way of eliminating them, as in the case of a popped balloon. Nature abhors not only a vacuum, but all gradients, which are, in fact, demonstrations of the availability of energy. Nature opposes availability. Whenever we increase a gradient and concentrate energy, we oppose nature.

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INTERIOR CLIMATE

Class I
• Temperature Moderated
• Vapor Pressure Uncontrolled
• Air Pressure Uncontrolled
Class II
• Temperature Controlled
• Vapor Pressure Moderated
• Air Pressure Moderated
Class III
• Temperature Controlled
• Vapor Pressure Controlled
• Air Pressure Controlled

Table 1: Interior climate classes.

There are four things we can do to maintain the quality of the interior air. We can heat or cool it. We can add or remove moisture. We can filter out contaminants. We can replace it with fresh air from the outside. This recovery air should be managed with a ventistat, which can be a standard carbon monoxide alarm that triggers a fan rather than an alarm. Recovery air should be managed very carefully because of the energy investment that is required to condition it and bring it up to the required standards.

We can alter the pressure, and this is a powerful tool in some cases. An inflatable life raft can be a lifesaver, and inflatable buildings are also becoming important. Air pressure should be kept in mind. When it comes to moving air, small squirrel cage fans are much more preferable than blade fans. A true squirrel cage fan is capable of building pressure, and can be used to maintain sufficient air pressure to support an inflatable building. Such fans will specify how much pressure they develop. They have aesthetic qualities that most people come to love, and they are very nice to have around. The control for this, and any other fan or pump, should be a three position[ON-OFF-AUTO] switch. Mostly it will be left on AUTO, where it is controlled by the ventistat. But whenever you open the windows of the house, you can enhance the effect by switching to ON. In general, a very small positive interior pressure seems to be a good idea.

Experience dictates that, In general, any automated devise should have a manual override. You, rather than HAL, should have the final say.

It will generally be more efficient to handle each aspect of air quality separately. Fresh air supply as described above is a single function process that stands alone for reasons of simplicity and transparency. Likewise, temperature control should be a single focus function that is controlled by a thermostat. Moisture control should managed with a humidistat.

These last two functions especially, should be totally separate and stand alone systems. This divide and conquer approach will greatly simplify everything, and this will allow us to isolate and evaluate the simple, natural, and passive processes of heat and moisture transfer that we are dealing with. This will bring about the evolution of understanding that we are in search of.

Recovery air can be preconditioned by bringing it in through earth tubes. Smooth walled PVC pipe is easily installed and maintained. These tubes should slope downwards towards their outside openings. A small rope can be installed and maintained inside any air tube. This will allow you to clean the tube by dragging a Clorox soaked cloth through it.

It may be a good idea to bring make-up air into an air-tight mechanical room, and begin the ventilation [distribution] system from there. This would house the inside unit of the heat pump, air filtering and pressurization equipment etc, and facilitate final conditioning of the recovery air, that might be coming through an earth-space in summer, and an isolated gain sun-space in winter. In a kitchen sink we have hot and cold running water. In a mechanical room we have warm and cool running air. At Haw Creek, the mechanical room was the earth-space, which is the most important part of the building, in terms of heat energy management.

Sun-space provides warmth. Earth-space provides "coolth" by absorbing warmth. It is exactly like mixing hot and cold water in the kitchen sink. A "sink" is a holding devise. A reservoir above a dam is a water sink. A devise that holds thermal energy is a heat sink.

We have seen how our atmosphere filters out those elements of empty space that are deadly to life. We have seen how our environment conserves the conditions for life on Earth. Suppose we look at a structure as an extension and continuation of this process. Since we can import our recovery air from either the sun-space or earth-space, for example, we have extended our ability to manage the interior environment viz selecting items from the environmental menu.

This particular example might lead us to think that perhaps we can manage the [Stack Loss](#) of the building as far as the temperature of inlet and stack air. In summer, the sun-space is vented to the atmosphere which creates a solar chimney effect that draws relatively cool air in through the earth-space. That cools the interior. In winter, intake air enters through sun-space.

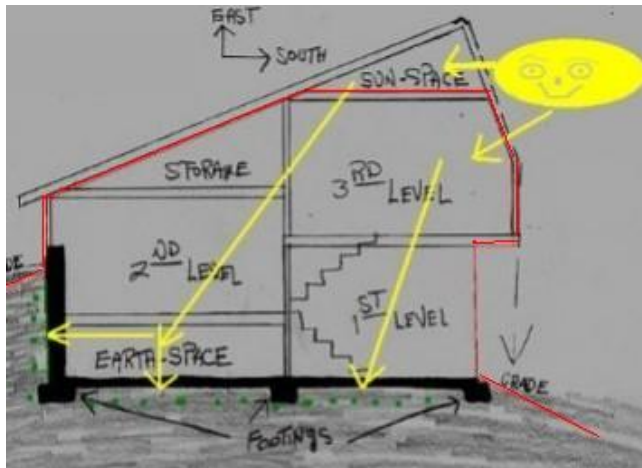
This is the entirety of it. There is no combustion factor, and that is the best part. Back-up heating and cooling is by ground source heat pump which requires no air exchange between the interior and exterior.

Within the structure, ceiling fans circulate air over the "working floors" viz tile floors that are thermally connected to the earth, and absorb energy or/and add coolth to the air. This adds the element of earth into the equation. Earth trumps Fire! Screen porches on the north side of the house are also working components of the structure as transitional spaces.

A garden spot is another example of an environmental interaction. In this case, Earth, Air, Fire, and Water are blended together in order to support favorable conditions for photosynthesis. In this, the environmental elements are filtered a little differently. Our viewpoint is that a working property should blend the elements of the environment, as in self-sufficient resource farming.

Water that strikes the roof should be directed away from the house and into the garden along with grey water. Red worms can recycle black water into nutrients that build soil. Everything gets recycled, and nothing is wasted. [Permaculture](#) is The Way and The Tao of the planet.

<Summer Storage cycle>

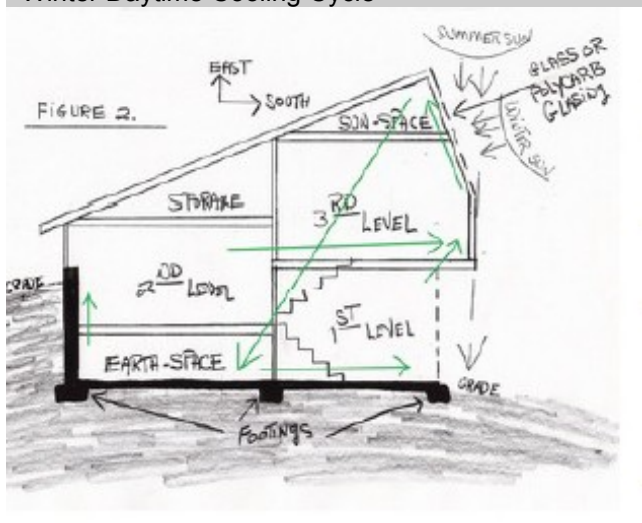


One essential task of the structure is to transfer thermal energy into the heat sink surrounding the foundation. This protects the interior environment from solar overload during the hot season just as a water reservoir prevents flooding during the wet season. Both continue to collect resources throughout the entire year. Sunshine is much more regular and manageable than water. We see long term drought and flooding, and climate seems increasingly erratic, but the brightness of the planet is stable.

The essential strategy of resource management and environmental protection is to distribute the

availability of a resource over time.

<Winter Daytime Cooling Cycle>



During the winter, warm sun-space air was circulated into the earth-space and then through the living space back to the sun space. This kept the daytime temp of the living space down to 80°F.

During the summer, the sun-space air was vented to the atmosphere via the thermal chimney effect of the structure.

This approach worked well in winter. In summer it was too warm. In retrospect, the ventilation system was too complex, and failed to maintain balance.

The concepts and principles of passive

conditioning worked exactly as expected. The balance of the structure could be improved by placing it a bit deeper into the earth in order to increase the flow of heat into the earth. It could be a bit more earthy, and a bit less sunny. The transfer of energy back and forth between the interior living space and the surrounding soil is exactly where the rubber meets the road in the art of passive conditioning. Given the concept of long term [time-lag] thermal storage, we need to develop some suitable metric with which to rate the thermal geometry of the total system. Probably the next step in the evolution of passive preconditioning techniques will be to include a ground source heat pump in the system. This will be a small backup system that will fine tune the system, and provide feedback data that describes system performance. Overall, it was a really good first attempt.

Because it was collecting and storing sunlight on an ongoing basis, net energy loads were low, and the house was constructed rather loosely like a barn. Barns last forever because they dry out in the wind. Houses rot from the inside out because they don't dry out, ever. This whole thing about air-tight construction has a really bad track record. It is an energy efficiency gimmick that has nothing to do with

conservation. In fact the energy paucity that we live with is created precisely because we conserve exactly zero. Let's look at what this is all about.

The interior living space of a structure can be entirely isolated from its environment and then conditioned as a closed thermodynamic system. This is necessary in space ships, airplanes and under sea vehicles that provide isolated life support systems within hostile environments.

Because of their motion through an otherwise friendly environment, automobiles too, must be air-tight and maintain self-contained climate control systems. Because they are designed to maintain separate and self-contained environments, discarded automobiles and space ships can become invaluable assets in hostile environments or off-grid situations.

The 12-volt automobile electrical system is the ideal conversion kit for any off-grid outpost. It is a complete and self-contained system that is capable of generating, storing, and utilizing electrical energy.

Additionally, an automobile body is air-tight and designed to shelter its occupants from high wind and rain. It is also well suited for the collection of solar energy. Half buried, it could be a dog house, chicken coop, or it could protect one from freezing. Used intelligently in this way, automobiles could greatly reduce rather than increase our carbon footprint.

The point of this digression is to point out that we don't live in outer space, and we don't need to isolate ourselves as if we did. Artificial, self-contained environments are costly, aesthetically displeasing and environmentally damaging. We have been programmed to think this is normal, which is to say that we have been normalized. Like milk, flour, and sugar, we have been standardized, pasteurized, homogenized, rectified, certified, and devitalized. Probably aliens from elsewhere would describe our species as over-processed and skull-flucked. They might think of us as Homo Fubar rather than Homo Sapient. We might wish to reconsider ourselves, hopefully sometime in the near future.

This site is about interacting with the natural environment, and is for those that would live back off in the woods somewhere in Rural, USA. We spoke earlier of civilizations being built on top of the remnants of previous civilizations. The automobile is an example of a resource that is eminently well suited for reallocation. It could reset our basal membranes and metabolism about how much electricity, and other energy we really need.

It has been said that [worms](#) build soil, and that everything else on the planet feeds the worms. Earth provides us with a friendly environment that spawns and nurtures life. She invites us to build interactive and cooperative relationships with her. Father in heaven provides, Mother Earth protects. Perhaps the true civilities of life are again to be found in the garden rather than at the fitness centers. Perhaps we're traveling the wrong way on [the yellow brick road](#).

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SUNSHINE, WATER, AND THE WATER MOLECULE

All resources are valuable, some are vital. The private water supplies that are maintained by individual landowners are, along with the public water supply, among the most vital. Good property management involves careful consideration of on-site water usage. Good resource management implies 100% usage, and zero% runoff for all water that strikes the building or property. This prevents downstream damage.

Sunshine that strikes a residential building should not cause overheating, which is a form of environmental damage. It should through-flow into the earth, and be conserved. Sunshine that strikes the property surface should be converted via photosynthesis into usable biomass.

Vegetable and worm gardening, poultry, fish and fire ponds, wind breaks, and other forms of conservation that involve the four elements of Earth, Air, Fire, And Water are all relevant.

Evidently, buildings, resources, properties, and environment are intimately connected in ways that are limited only by our imagination. It is in this context that we might see ourselves and Planet Earth as one interactive and homeostatic system.

This does not imply a return to earlier more difficult times. People are not that tough anymore. It means weaving our technology, experience, and consciousness into a new blend that was not previously possible. It means growing a new mentality. The Internet provides us with a way to stay connected over distances. This can downplay the use of the automobile and its many aftereffects. It can promote the return of rural communities and their many benefits.



We have seen that sunlight and water travel together as one of the most powerful forces on the planet [enthalpy]. Warm, moist air has greater energy capacity than cold dry air, and this is one of those basic properties of matter and energy that conserves life on the planet.

The water molecule is the most wonderful, mysterious, influential, powerful, and sought after molecule in this man's universe. It is omnipotent, and omnipresent in the ongoing creation of our world. It has also been the most damaging to man made infrastructure.



Next to man, the beaver has most changed the surface of the planet. In building dams that hold water on the surface, the beaver increased the "wetness" of the planet, and in this way added blue/green to the Earth. But they were inconvenient to us, and are mostly gone now. The inhospitable environment that they created was in violation of our zoning laws. To interact with the environment in ways that hook into the tremendous natural resources of this living planet is what we have forgotten. We have invented devices to oppose nature, and we have successfully disposed of both The American Beaver and The American Indian.



Energy has become the greatest show on earth, and we have electrocuted the planet. In a few years there will be no more water. Electricity turns the blue/green planet to yellow. The little shrubs in the picture are artificial. This is the "much more hospitable" environment that lies in the middle of the road that we are on. The image is from an advertisement for solar panels. The same corporation sells bottled water.



Mars, the red planet, is much colder than Earth, because it receives much less solar energy, and it does not have an atmospheric blanket as does Earth. Scientists suggest that there may be much more water beneath the surface than previously thought, and water is the key to [Terra-forming Mars](#). A dome on the Martian soil as pictured above would soak up sunlight, and drag subsurface water to the surface. Eventually, they say, Mars could get green, but not within the lifetime of Earth, the former green planet.

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DIFFUSION AND CONCENTRATION PROPERTIES

A concentration gradient exists whenever a concentrated solution is in contact with a less concentrated solution. Because the solutions are in contact, particles may flow between the two solutions (or between two regions of the same solution) by the process known as diffusion.

Diffusion is a term used to describe the mixing of two different substances that are placed in contact. The substances may be gases, liquids, or solids. Diffusion is the migrating by random motion of these different particles. Although particles move in every direction, there is a **net flow** from the more concentrated solution to the less concentrated solution ("down the concentration gradient"). As the number of particles in the more concentrated solution diminishes and the number of particles in the less concentrated increases, the difference in concentration between the two solutions decreases. Hence, the concentration gradient is said to get smaller. All else being equal, the concentrations of the solutions change more rapidly when the difference in their concentrations is greater. This diffusion process continues until the concentrations of the two solutions are equal. This state is known as dynamic equilibrium.

When the two solutions are in dynamic equilibrium, particles continue to move between the two solutions, but there is no net flow in any one direction, *i.e.*, the concentrations do not change.

This is just another example of the second law as it applies, in this case, to molecular diffusion in gases. It is important to consider this when we chose building materials. As stated previously, we chose masonry because of its fail-safe storage and diffusion properties which allow us to skip over these somewhat difficult issues for now. But things pointed to are important beginnings of ideas yet to be developed. The point of this paper has been to raise questions and point to possibilities about the design and construction of buildings that will need to be explored further. Often they have been considered previously. One of the main ideas of [Organic Architecture](#) is that materials and properties of matter are essential design considerations in buildings.

Construction techniques evolve through the actual hands-on construction process within different [hygrothermal regions](#) or [Climate Zones](#)

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Organic Gardening: An Introduction To Organic Architecture



Life on Earth is the history of recycling waste. If one gathers the fallen leaves of Autumn and tills them into the soil of a garden spot, the [Decomposers](#) will absorb and recycle them into nutrients that the [Producers](#) will again use to convert sunlight to biomass through the process of photosynthesis.

To prepare the soil in this way is to participate in the cosmic dance. Life is a process of creation in which the music never stops, the dancers never tire, and the dance never ends. Soil, a living organism is one of the creation elements of the dance. To decorate the ballroom a bit, we will add other organic material such as coffee

grounds, grass clippings, vegetable waste, sawdust, newspaper, etc. This is the dance of life seeking after itself. It is a process in which everything gets recycled, and there are no remainders.

In this natural process, The Creator and The Created are one and the same. As Earth, Air, Fire, and Water conspire in the processes that create a tree, so too the tree reorders those elements, reorganizes the flow of energy, and recreates the environment. Planet Earth is an organic garden. It is life seeking after itself.

Buildings too, alter their surrounding micro-climate, and therefore participate in their own environment. They interact with the natural forces of earth, wind, sun and water, and can be designed to Collect, Convert, and Conserve energy just as trees, gardens or sailboats do

Buildings can be designed to manage and recycle environmental energy just as the processes of nature do. Their functioning can be patterned after the living processes that maintain equilibrium and

homeostasis on Planet Earth. And, they can be designed to cooperate with, rather than oppose the conservation principles of energy and matter that rule over this entire universe.



At this point we don't know how to build a structure that will house people, so we'll build a structure that will house a garden. We know that plants gather energy and warmth from sunlight, and we know that soil keeps them cool and moist. To optimize these relationships, we can gradually increase the amount of sunlight that strikes the soil by selectively removing trees. We can also collect and conserve water that falls on the property for gardening. City water is chlorinated and increasingly expensive. We want to eliminate all water runoff because it incurs added costs to the downstream environment. Zero runoff implies good resource management and environmental protection. Our goal is full utilization of all natural resources. Of

the four resources, air is the only one that remains outside of our jurisdiction.

Charles Darwin felt that earthworms were one of the most important species on this planet. His viewpoint was that worms build the soil and everything else feeds the worms. Perhaps we should consider our species trivial in comparison. Worms have four requirements: temperature, moisture, food, and PH balance. The last is managed by adding powdered limestone or eggshells to the soil. All in all, it is pretty easy.

Everyone in our neighborhood rakes leaves in the fall, puts them in bags, and carries them to the street where the city picks them up and disposes of them. Everyone that is, except us. We go around and collect leaves, chop them up with a lawnmower and till them into the soil around the house in order to feed the worms which are our personal employees. We are a part of the organic garbage cycle. We are part of the organic recycling process. We are part of the dance.

If Darwin is correct, the best way to grow organic vegetables is by gathering organic matter to feed the worms that build the soil that nourishes the garden. This is one of the oldest forms of renewable energy. This recycling of organic matter transforms the soil into a living organism that, once initiated, is self-perpetuating. Building soil is every bit as interesting as constructing buildings. It is an honor to be assistant and attendant to final state conditions and new beginnings that one uncovers in the garden. Suite101.com is a good beginning to living in the natural world.

In the end, Earth, Air, Fire, and Water will prove more enduring elements of steady state conditions than either the rocket science of Von Braun or the full employment economic theory of Keynes. Man-made disequilibrium will give way to the dynamic equilibrium adjustment and regulation mechanisms of planetary homeostasis. Man will prevail only briefly, perhaps, but in that time we can choose to amuse ourselves in whatever way we wish.

Worms are cold blooded creatures that do well at temperatures somewhere within the limits of annual soil temperature variation. Their activity is optimized at around the same temperatures in which humans are

comfortable [70°F.] This, coincidentally, is around the average annual soil temperatures that can be easily maintained by insulating the soil at its interface with the atmosphere. This triple coincidence should not be ignored.

If we're not able to consider building environmentally neutral habitat for humans just yet, we can at least practice constructing habitats that maintain good soil conditions for the organisms therein. We have dealt with food, water, and PH balance of the soil, and now we have only the consideration of soil temperature. Perhaps we could grow a structure out of the earth and into the sunlight. That works for plants, and if we reiterate this process, we might further reduce the temperature variation of the soil throughout the year by simply replicating the green house effect. So we'll begin our journey with an earth-sheltered greenhouse.

At the least, we can expect reductions in the energy loads of greenhouses, as well as increased photosynthetic activity due to improved soil conditions. Any benefits in energy transfer at this level will benefit our species in a natural, non-toxic approach to resource management and environmental protection. Bio-energetics studies the flow of energy through species or systems, and our species is totally unbalanced.

Consider a rocket engine that is designed to burn energy fast enough to attain escape velocity, while not becoming a firecracker. The line between the two is very thin indeed, and this level of dynamic disequilibrium is exciting, but short lived. Our consumer economy is a similar devise. We talk about resource management and environmental protection, but not seriously. In terms of planetary homeostasis, our lifestyle is not even close to sustainable, and we seem to have no alternative.

If we wish to consider species longevity, we have to think of final state, end state, or equilibrium state conditions that conserve life on earth. After all, we are [consumers](#) and we stand very close to the cows that we feed upon, and that should be just a little bit troubling to you, cousin!

In order to maintain satisfactory temperatures within our buildings, we buy energy from the guys that sell energy. A more natural idea for maintaining an [energy balance](#) is to replicate the atmosphere of the planet. But to make this work must combine the qualities of Earth and Fire together in an ongoing process.

Think about this as a means of altering the interface between soil and atmosphere, so as to maintain fairly stable soil temperatures throughout the year. This in turn can extend growing seasons, enhance photosynthesis, and improve soil quality. A schematic of this is concept is shown in the lower portion of Figure 17. It could also be constructed as a separate free-standing structure.

<Figure 17>

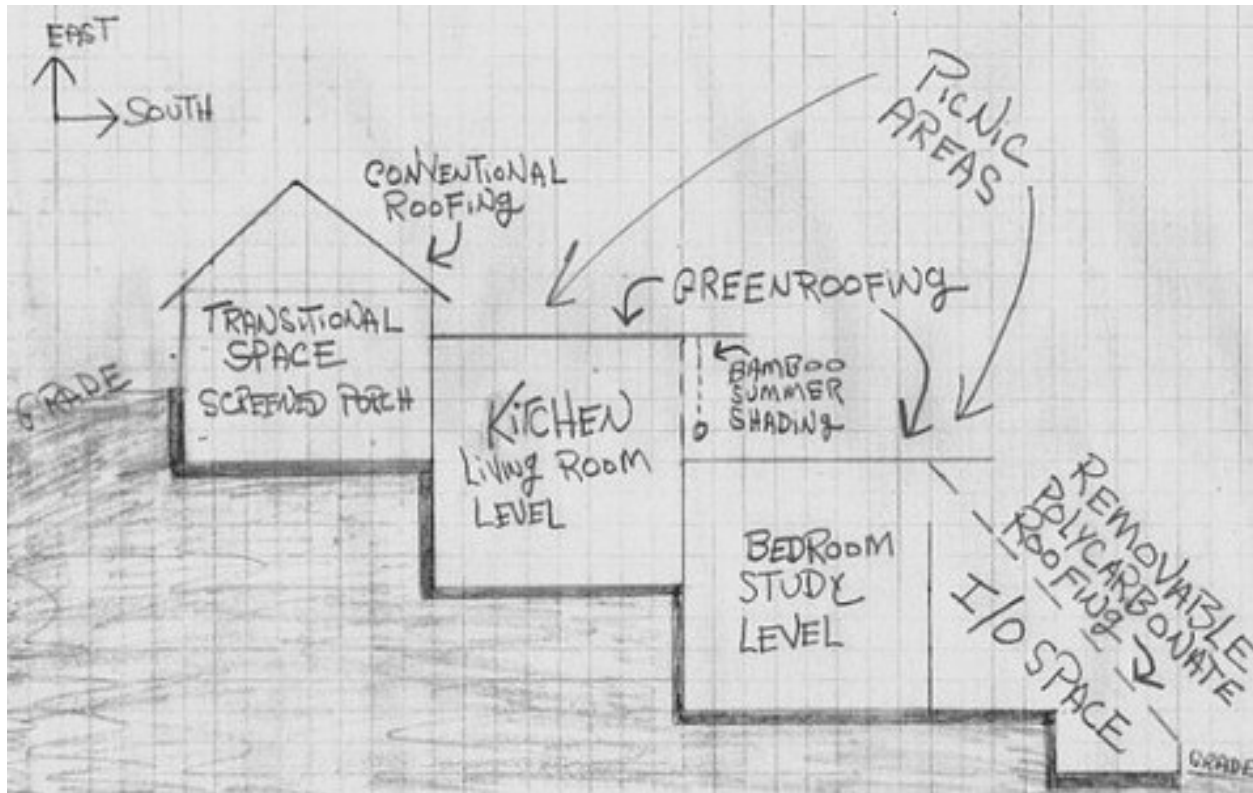


Figure 17 presents a schematic in which the living space and earth space are the same space. The sun-space is located below that, and this allows warm air to flow up and into the house by buoyancy. The I/O space [inside/outside space] is a convertible space that can be easily enclosed, or left open at different times of the year. This could be an inflatable space, a removable clear polycarbonate cover, or clear plastic material.

In summertime, cooler air from the screen porch will gravity flow down into the living spaces, and replace warmer, rising air that leaves by means of a solar chimney effect. The "green-roofing" is really artificial turf, which will provide the cladding for the roof control layers, without the problems of real grass. These areas are more like open decks, although some kind of top or hat could be installed above. One could do light containerized herbal gardening here, but the lower grade level I/O space and south yard would be the main gardening areas.

The best kind of roof in terms of durability, storm protection, and thermal mass is concrete, but again, this drawing is a mere concept that presents ideas which are completely site specific. Building design is nested in site design. Site design is nested in environmental interaction which requires expanded consciousness.

In all of these ideas, we would expect some collaboration from gardeners, physicists, and farmers. We would not expect much support from home builders, building supply companies, building inspectors and comfort control companies.

It spits man back into the natural world and says sink or swim. At the moment it is a voluntary and optional program similar to any other enlistment opportunity. Not everybody can go to Mars. Somebody has to think about about establishing a [Permaculture](#) here on our home planet.

Since the above installation is essentially a solar energy capture devise, it could be used as a hot water pre-heater, or part of a seasonal thermal energy storage system. After all, the most efficient way to use solar energy is to convert it into low-temperature thermal energy at the point-of-incidence which is also the point-of-use.

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Soil Temperature

<Image101>



Image 101 shows a 9X12 clear plastic tarp that has been placed over what will be a bed of wildflowers.

Package instructions say the seeds will not germinate until the soil temperature reaches 60 degrees F. which did not happen last year until the middle of June. We wish to warm the soil a bit earlier this year, and this is our first attempt at doing this.

As stated previously, soil temperature is a dependent variable that can be controlled by managing the interface between soil and atmosphere. We will begin to consider

techniques for doing this because of the great importance that soil temperature has in farming, gardening, and other processes of photosynthesis. Soil temperature is equally important in the process of transferring solar thermal energy into forms that are available [or unavailable] in small buildings.

Again, our claim is that solar energy, like water, will cause "flooding" during parts of the year, and that by collecting and storing such excess, we can distribute both commodities over time, and make much better use of them.

We wish to have warm soil in winter and cool soil in summer. We wish the summer soil to be cool so that it will accept the excess heat that we wish to "sink" into it. Likewise, we want water reservoir levels at the beginning of the rainy season to be low enough to provide storage capacity for potential flood waters. We keep repeating this statement of strategy because conservation is so foreign to our way of managing energy.

In the early 21ST century most efforts are aimed at converting sunshine into electricity which is pretty damaging to the planet, and therefore expensive. But it does keep energy in the hands of the sellers, and maintains the role of the people as buyers. Energy density, like consumer credit, promotes economic and population growth, and that is the way of the world these days. It is well understood that conservation is

anti-American, and the idea of people living in symbiosis with the planet is indeed rather childish, but it is my way of amusing myself.

For those few that would like to move away from The Grid, and are willing to give up the fitness center for the backyard garden, we will continue to developing ideas of capturing, converting, and conserving energy from the natural environment rather than purchasing it from the electric company. We are not trying to go completely off-grid, and we are not trying to undermine the system. We are simply exploring different possibilities, and this paper is little more than an introduction to a different approach and an alternate lifestyle or reality.

In the above experiment, changing the soil temperature is full of surprises. Surprise is wonderful because it informs us of the mysterious and the unexpected. It removes the drudgery of the controlled and predictable. Nature, for those that are able to suspend the security for the spontaneous, is full of new beginnings. One lesson learned last year was that wildflowers have a dramatically different effect on soil than a grass lawn does. Grass tends to compact the soil while wildflowers loosen the soil. Already we need of a better understanding of soil science and soil ecology if we wish to sustain our kind. Grass sustains lawn service companies only.

If we compare the effects of our species on Planet Earth with the effects of earthworms or other decomposers that are clearly a part of the life process, we might see the source of our own psychosis. This statement may be extreme, but there is no doubt that gardening does wonders for the human soul.

Earthworms are cold blooded creatures. They can not survive freezing nor temperatures above 80°F. Within this range, their activity is maximum at around 70°F, which is very close to human comfort zones. If we develop ways to alter soil temperature, we might coincidently benefit our efforts at both gardening and housing. But we have to do this on a small scale so that the problems we might create are also small scale. At this point, we think that increasing soil temperature by 10°F might be feasible, but we have much to learn about how this will affect the nature of things. This might double microbe activity, for example, and change soil chemistry, but we are talking very small scale [individual building sites] rather than massive [Mississippi river type] projects.

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Planet Earth: The Way of the World

As you see, we are pretty much telling the same story as before, and only the context around the story changes.

